INJURY INCIDENCE AND RISK FACTORS IN CROSSFIT® ATHLETES IN JOHANNESBURG

A research dissertation submitted to the Faculty of Health Sciences, University of Johannesburg, as partial fulfilment for the Master's degree in Technology, Chiropractic by:

Marius Louis Steenkamp

(Student number: 201007209)

Supervisor: ________________________ Date: _________________________

Dr. C. Hay

DECLARATION

I, Marius Louis Steenkamp, declare that this dissertation is my own, unaided work. It is being submitted as partial fulfilment for the Master's Degree of Technology, in the program of Chiropractic, at the University of Johannesburg. It has not been submitted before for any degree of examination in any other University.

Marius Louis Steenkamp

On the 24th day of the month November 2020

DEDICATION

To my family – Erika, Marius, Marika and Nicholas – For your endless support and patience. Thank you for always standing by me throughout this long journey.

To Anne, my better half – Thank you for always encouraging me, loving me and always standing by me in the best and worst of times. I could not have done this without you.

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Thank you to the gym owners and coaches that agreed to have their gyms and members take part in this study.

Lastly, thank you to all the athletes that took the time to fill in my survey, without you this would not have been possible.

ABSTRACT

Introduction: CrossFit® is a training methodology that utilizes a combination of functional movements performed at a high intensity to increase fitness levels in its participants. Even though it has had great success as a training methodology, CrossFit® is plagued by claims of rampant injury and has been criticised for having a potentially disproportionate high rate and risk of injuries. Research relating to injury rates and risk factors in CrossFit® has been scarce, especially in South Africa.

The aim of this study was to investigate the incidence of injuries and risk factors related to CrossFit® participation in South Africa. This research topic could potentially contribute to the presently scarce body of literature and broader society as it would inform CrossFit® athletes and their coaches about potential risks for injury and how they might be prevented.

Method: Emails containing the information and consent forms as well as a link to the online survey were distributed to registered CrossFit® gymnasiums within Johannesburg. The same email was then distributed to athletes via each gymnasiums membership database. Athletes who wished to participate in the survey could do so by clicking on the link provided. The information and consent forms contained all the relevant information about the study and clearly stated that by clicking on the link provided, participants were giving consent to participate in the study. The survey was completely anonymous and asked questions relating to participant demographics, training history and injuries. The survey was based on a similar study and adapted with the help of STATKON. The survey link was live from the 2nd of June to the 27th of July 2020. Out of 21 gymnasiums 250 valid responses were recorded.

Results: The study reported a CrossFit® related injury incidence of 60.2%. The most commonly injured body regions, for both males and females, were the shoulder, lower back and knee. Gender was shown to be the most significant risk factor with males reporting more injuries than females. The average time participating in CrossFit® prior to sustaining an injury was 1.2 years for females and 2.3 years for males. The most common type of injury was

overuse injury and the activity during which the majority of injuries occurred were workouts of the day (WOD).

Conclusion: The injury incidence of CrossFit® related injuries in this study was 60.2%. Although this may seem high, compared to most recreational activities such as running it is not high. The results of this study were similar to those found in the literature. With correct coaching and supervision CrossFit® could be practiced safely by participants of any age, gender, ability or skill level and has been proven to be an effective form of exercise.

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CHAPTER 1 - INTRODUCTION

1.1 The Problem and its Setting

The health and fitness industry have never been bigger or more profitable, yet as a country, South Africa is facing an obesity epidemic. Exercise has become more than just a hobby; it has evolved as a key factor to healthy living. The past two decades have seen many different fitness methodologies appear on the scene. One of the stand outs have been CrossFit®. Ever since its inception in 2000, founder Greg Glassman has advocated CrossFit® as a training methodology to improve physical fitness and performance (Fernandez, Sabido-Solana, Moya, Sarabia and Moya, 2015).

CrossFit® utilizes functional movements performed at high intensity over varying time domains to increase work capacity (Bellar, Hatchett, Judge, Breaux and Marcus, 2015). It has seen great success as a training methodology and, even 20 years later, is still seeing exponential growth worldwide as more and more Affiliates (registered gymnasiums) open every day.

Despite the continuing growth, CrossFit® is plagued by claims of rampant injury. It has been criticised for having a potentially disproportionate high rate and risk of injuries (Kliszczewicz, Quindry, Blessing, Oliver, Esco and Taylor, 2015). Some even going so far as to publish academic studies with falsified data in attempts to strengthen the false claims of high injury rates. The aforementioned study was later discredited, though the damage had still been done, and 7 years later the stigma remains in the eyes of the uninformed and media (Bergeron, Nindl, Deuster, Baumgartner, Kane, Kraemer and O'Connor, 2011).

Prior to 2013 there was almost no credible research done with regards to CrossFit® but since then new research has emerged at a steady trickle. Research relating to injury rates and risk factors in CrossFit® are still lacking, especially in South Africa. Due to the limited amount of research and the rapid growth of the CrossFit® community, the safety of becoming a CrossFit® athlete has been questioned.

1.2 Aim of the study

The aim of this research was to investigate the incidence of injuries and potential risk factors related to CrossFit® participation in Johannesburg, South Africa.

1.3 Benefits of the Study

The possible outcomes of this study would establish whether the research of incidence of injuries and risk factors related to CrossFit® participation within a South African context, correlates with similar studies done abroad and possibly contribute to a presently scarce body of literature.

The outcome of this study could also potentially contribute to the broader society, as it would inform CrossFit® athletes and their coaches, about potential risks for injury and how they could be prevented. The relevance hereof, in terms of the healthcare professions, is highlighting gaps in a South African CrossFit® context, expanding knowledge on injuries, planning provision for safer exercise programs, and improving the practice of CrossFit®.

CHAPTER 2 - LITERATURE REVIEW

2.1 What is CrossFit®?

CrossFit® is a strength and conditioning training methodology that utilizes constantly varied, functional movements executed at high intensity to help participants improve their health and physical adaptations (Glassman, 2010). This could result in increased strength, power, cardiovascular/respiratory endurance, stamina, speed, flexibility, coordination, agility, balance, and accuracy (Claudino, Gabbett, Bourgeois, Souza, Miranda, Mezencio, Soncin, Filho, Bottaro, Hernandez and Amadio, 2018; Smith, Sommer, Starkoff and Devor, 2013). This program consists of a "Workout of the Day" (WOD) which included a variety of exercises including gymnastics, weightlifting, running, rowing, bodyweight, skipping and moving peculiar shaped objects (Martinez-Gomez, Valenzuela, Barranco-Gill, Moral-Gonzalez, Garcia-Gonzalez and Lucia, 2019). A typical CrossFit® class would usually start with a warmup (e.g. easy running, skipping or rowing to get the heartrate and body temperature elevated), and mobility work, followed by strength building exercises or specific skill work. After this, the instructor would go through the WOD that is to be performed, demonstrating correct movement and what faults to avoid, as well as providing movement substitutions for any members that aren't able to complete the workout as prescribed (Costa, Louzada, Miyashita, Silva, Sunglaila, Lara, Pochini, Ejnisman, Cohen and Arliani, 2019; Sprey, Ferreira, Lima, Duarte, Jorge and Santilli, 2016).

Each WOD is scalable. This allows a variety of people on different strength and fitness levels to participate. Thus, individuals ranging from beginner to advanced could participate in a group setting. This scalability plays a key role in the popularity of CrossFit®, and its claim that the training methodology is suitable for everyone, whether they be elite, pregnant or disabled (Szeles, Costa, Cunha, Hespanhol, Pochini, Ramos and Cohen, 2020). However, WOD's often involve a competitive element (Hak, Hodzovic and Hickey, 2013; Mehrab, De Vos, Kraan and Mathijssen, 2017).

CrossFit® gymnasiums are called Affiliates or Boxes, and their members are called Athletes (Szeles et al., 2020). Each gymnasium that is registered with CrossFit® Inc may use the trademark in the naming of their gymnasium, after paying the yearly affiliation fee. Registered gymnasiums' names and locations are published on the CrossFit® webpage (CrossFit®, Inc., 2020).

CrossFit® has its own courses by which trainers were certified called the CF Levels 1 to 4, and multiple other specialty courses like Olympic Weightlifting and Gymnastics Levels 1 and Level 2. To register a CrossFit® gymnasium the head coach must be in possession of a valid CF Level 1 certification (with a 5-yearly renewal). This two-day seminar included theory lectures on the CrossFit® methodology, practical movement competency evaluation, and a written test at the end of the second day, requiring a pass mark of 75% (CrossFit, Inc., 2020). This meant that although every gymnasium was responsible for their own program design, the same principles were followed worldwide, as taught in the CF Level 1 (Szeles et al., 2020).

Although thousands of gymnasiums use the trademark CrossFit®, it does not follow any franchising model. Unlike most large corporation fitness chains, CrossFit® does not supervise its registered gymnasiums. Instead, it provides coaches and owners with the freedom to grow and develop on their own and not requiring them to follow daily programming produced by CrossFit® headquarters. Therefore, the quality might vary between gymnasiums based on the experience of coaches and owners, but all still follow the core methodology. CrossFit® maintained that in a free market economy, the best gymnasiums with good coaching and management would thrive while those with poor management and bad coaching would flounder (Weisenthal et al., 2014).

Since its inception in the year 2000, Greg Glassman, the founder and CEO of CrossFit® Inc, established the CrossFit® methodology and opened the first affiliate in Santa Cruz, California. Since then, the number of affiliates had seen continuous exponential growth and currently stands at over 15,000 affiliates worldwide (CrossFit®, Inc., 2020).

2.2 Concerns about Safety

Every form of physical exercise is and has always been, associated with a relative risk of injury. Whether it be walking, running, cycling or rugby, the risk of injury is always present (Oh, 2013). Montalvo, Shaefer, Rodriguez, Li, Epnere and Meyer (2017) noted that with a rapid increase in participation and limited associated literature on injury epidemiology, CrossFit® has been questioned for its safety (Summitt, Cotton, Kays and Slaven, 2016). The potential danger of participating in CrossFit® has been noted by media outlets and newspapers because of the unusual combination and sequence of exercises (Montalvo et al., 2017). The high intensity and competitive nature of the workouts, as well as the decreased attention given to technical aspects compared to similar high intensity sports including powerlifting, Olympic weightlifting, gymnastics and rugby, had also contributed to the concerns. Additionally, the loss of good form during workouts that were timed, may lead to injury (Hak et al., 2013; Summitt et al., 2016).

Additionally, CrossFit® has been linked with reports of rhabdomyolysis, a potentially lethal condition resulting from the breakdown of muscle tissue, characterised by pain, weakness, swelling and blood in the urine, which could lead to renal failure and death. When occurring due to exercise it is called exertional rhabdomyolysis. Even though rhabdomyolysis and CrossFit® were often spoken of as going together hand-in-hand, clinically confirmed cases were quite rare (Mate-Munoz, Lougedo, Barba, Garcia-Fernandez, Garnacho-Castano and Dominguez, 2017). In fact, common recreational physical activities such as resistance training, indoor cycling, and even Ultimate Frisbee have resulted in cases of exertional rhabdomyolysis. Development of rhabdomyolysis might also be associated with genetics (e.g., sickle cell trait) or acquired conditions (e.g., drug use or trauma). In adults, the most common cause was usually illicit drug usage, trauma or alcohol abuse. The main diagnostic criterion for rhabdomyolysis is laboratory-based quantification of the enzyme Creatine Kinase and could not be diagnosed by physical findings alone (Feito, Burrows and Tabb, 2017; Tibana and Sousa, 2018).

2.3 Safety According to the Literature

There has been a potential risk for injury in every form of physical activity long before CrossFit® was established (Meyer, Morrison and Zuniga, 2017). According to literature, the highest rates of injuries in CrossFit® were in the shoulders, lower back and knees respectively (Fetio et al., 2018; Montalvo et al., 2017; Mehrab et al., 2017; Weisenthal, Beck, Maloney, DeHaven and Giordano, 2014). Although there has been much concern regarding the high-profile injury rates in CrossFit®, the literature was contradictory (Costa et al., 2019). There has been a lack of objective evidence regarding injury profiles and the safety of doing CrossFit® (Hak et al., 2013).

While several studies have highlighted the benefits of doing CrossFit®, other studies have reported disproportionate musculoskeletal injury rates ranging from 19.4% to 73.5% (Hak et al., 2013; Mehrab et al., 2017; Mantalvo et al., 2017; Moran, Booker, Staines and Williams, 2017; Sprey et al., 2016; Weisenthal et al., 2014). However, most of these studies used a retrospective design. Systematic reviews found the existing literature on CrossFit® related musculoskeletal injuries to be of low quality due to the high rate of bias within these studies (Claudino et al., 2018).

One of the biggest issues with most of these studies were the inconsistencies of the definition of the injury. Some studies reported 10 times the number of injuries because they considered the injury criteria to be any injury that leads to at least 1 day of training missed (Szeles et al. 2020). Other studies used 1 week of training missed; 2 weeks of activity modification; or having to consult a healthcare practitioner or specialist, as part of their injury criteria (Mehrab et al., 2017; Weisenthal et al., 2014).

Within other sports, such as basketball, baseball and handball, there has been strong evidence linking previous injuries with increased risk of injuries in the future (Szeles et al., 2020). Chachula, Cameron and Svoboda (2016); Moran et al. (2017), and Costa et al. (2019) found that participants with injuries sustained prior to starting CrossFit®, were up to 3 times more likely to sustain a CrossFit® related musculoskeletal injury. Three hypotheses were proposed to explain why this could occur: scar tissue; inappropriate load; and diagnostic or treatment factors. Firstly, it was proposed that scar tissue could lead to future muscular imbalance, causing a reduction in flexibility, leading to mechanical or functional instability. Second, time away from exercise programs could result in athletes inadequately balancing acute and chronic loads, upon resuming activity. Thirdly, previous injuries could have remained undiagnosed and untreated, until such time of starting CrossFit®, when it would then flair-up and be deemed a CrossFit® related musculoskeletal injury (Szeles et al., 2020).

Szeles et al. (2020) also found that one year of CrossFit® experience, decreased the injury rate by half. This directly contradicts research by Montalvo et al. (2017), who stated that the more CrossFit® experience participants had, the higher the likelihood of injury. The reasoning behind this could be that the more experience that was gained in CrossFit®, the higher the participants work and load capacities, and thus could have an increased chance of sustaining an injury (Costa et al., 2019).

Costa et al. (2019) reported an injury rate of 36%, majority of which were shoulder injuries and second most, were low back injuries. This study used the injury criteria from Mehrab et al. (2017) and Weisenthal et al. (2014). These criteria entailed meeting one of the following: a) missing 1 week of training, b) 2 weeks of activity modification during training or c) consulting a specialist. The study also looked at comparing injury rates of participants who only do CrossFit®, to those who participate in other sports and CrossFit®, reporting no difference in injury rate between the two groups. Seventy-nine-point two percent of the participants in this study reported taking part in other sporting activities, other than CrossFit®, yet the authors admitted that it was impossible to assume that all injuries were caused by a single sporting modality.

Elkin, Kammerman, Kunselman and Gallo (2019) investigated the likelihood of using medical care post injury between traditional weightlifting and CrossFit® participants. They found that CrossFit® participants were 1.3 times more likely to sustain an injury, with an injury incidence of 60.67%, but were 1.86 times more likely to seek medical attention compared to traditional weightlifting participants. Shoulder injuries were predominant, followed by lower back injuries. The study found that for every 10 years of additional age of the participants, the injury rate seemed to decrease by 13%. Unfortunately, this study did not provide a definition of injury and did not take previous injuries into account.

In 2018, a four-year study, surveyed 3049 participants using an online questionnaire of which 931 reported a CrossFit® related musculoskeletal injury, producing an injury incidence of 30.5%. Majority of injuries were shoulder and low back related, making up 39% and 36% respectively of total injuries. Males reported more injuries compared to females. The study showed an increased injury risk for participants (1) within their first year of CrossFit®; and (2) who train CrossFit® less than three days per week. The study suggested closer supervision of participants in their first year of training to minimize risk of injuries. Injury definitions had not been clearly defined. It was concluded that CrossFit® was no more dangerous or extreme than other exercise programs and was in fact found to have a lower injury rate than traditional forms of exercise (Feito et al., 2018).

Aune and Powers (2017) surveyed 247 athletes and reported an injury incidence of 34% reported at least one CrossFit® related musculoskeletal injury. The largest percentage of injuries were to the shoulder area, making up 15% of total injuries. Athletes with previous shoulder injuries were 8.1 times more likely to reinjure their shoulders compared to their uninjured counterparts. Four exercises (squat cleans, ring dips, overhead squats and push presses) were found to be significantly problematic, all four placing significant loads on the shoulders.

Men were likely to be injured more frequently. However, compared to women, it was found that men spent more time training and had more lifetime hours of training. Similar to Feito et al. (2018), the study also found that new athletes were at higher risk of sustaining an injury compared to more experienced participants. It was concluded that the rate of injury was similar to weightlifting and other recreational activities. Additionally, majority of participants reported taking part in activities apart from CrossFit® such as running/jogging, weightlifting, and cycling. Once again, no injury definition was provided, and participants were only allowed to list one injury per anatomic location (Aune and Powers, 2017).

A review of high intensity functional training methods by Tibana and Sousa (2018) looked at the six most significant studies published between 2013 and 2018. It reported that between the six studies, there had been no consistent injury definition and demographical information was lacking. Therefore, it could not be established what each participants' goals were, whether they be competitive or for general health and fitness (Tibana and Sousa, 2018).

Grier, Canham-Chervak, McNulty and Jones (2013) reported an injury prevalence of 41% out of 1393 US army soldiers. They described injuries by type ranging from overuse to traumatic. All 6 studies found that the anatomical areas most frequently reported to be injured were the shoulders, spine and knees, as shown in figure 2.1. Hak et al. (2013) reported an injury incidence of 73.5% out of 132 participants. They also noted higher prevalence of shoulder injuries due to frequent combination of hyperflexion, internal rotation and abduction, placing the shoulder in positions of higher risk especially when fatigued. This position of the shoulder is perfectly illustrated by figure 2.2 and frames 16 to 18 in figure 2.3 on the following page.

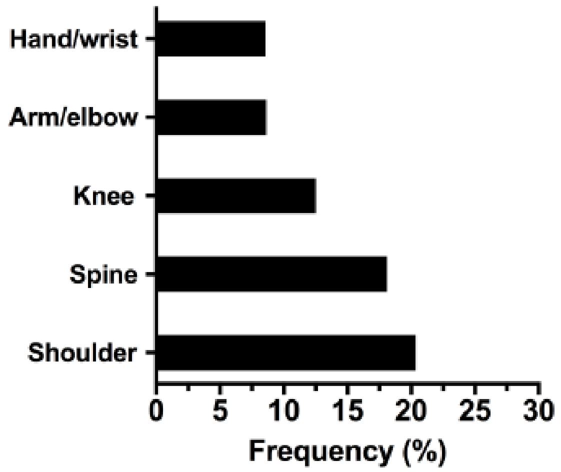

Figure 2.1: Summary of the most frequent injuries caused by extreme conditioning programmes by different authors (Aune and Powers, 2017; Grier et al., 2013; Hak et al., 2013; Mehrab et al., 2017; Montalvo et al., 2017; Summitt et al., 2016; Weisenthal et al., 2014).

Mehrab et al. (2017) reported an injury incidence of 56.1% out of 449 participants. Montalvo et al. (2017) reported an injury incidence of 26.2% out of 191 participants. Summitt et al. (2016) focussed only on shoulder injuries and reported an injury incidence of 23.5% out of 187 participants. Weisenthal et al. (2014) reported an injury incidence of 19.4% out of 386 participants.

Figure 2.2: A common fault, especially in beginners, during the Bar Muscle Up aptly named "the chicken wing" (RX'd photography, 2020)

All six studies reviewed by Tibana and Sousa (2018) reported higher injury incidence in men compared to women. Previous injuries greatly increased the risk of re-injury to the same region or causing compensation leading to injury in a different anatomical region (Tibana and Sousa, 2018).

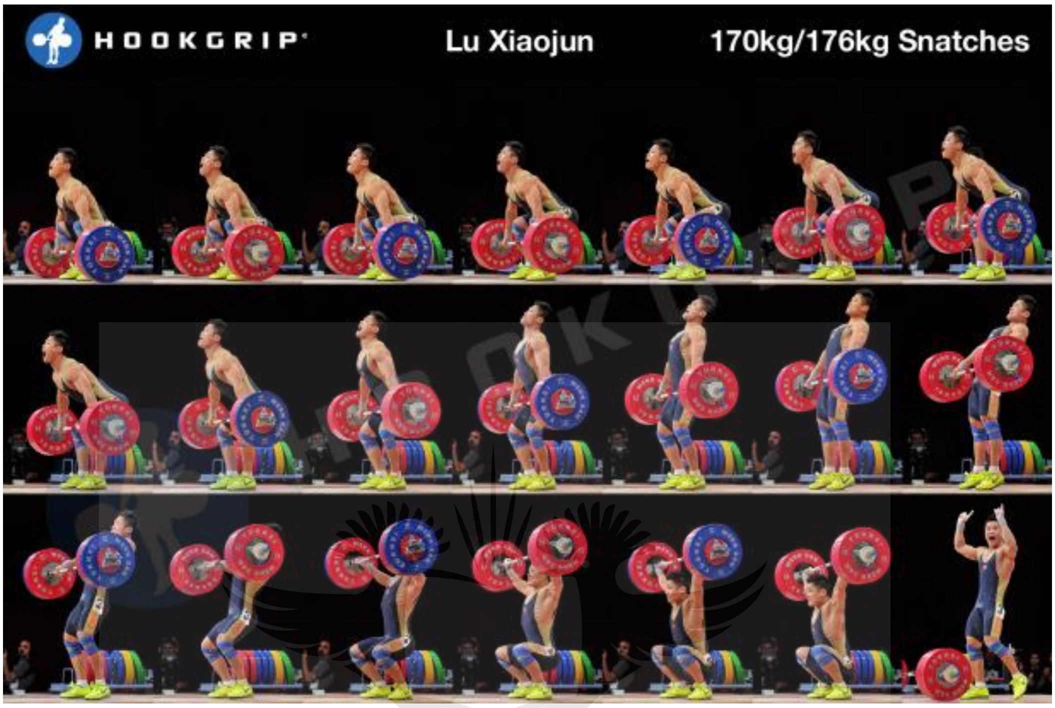

Figure 2.3: The Snatch (Hookgrip, 2020)

2.4 Compared to Other Sports

Overall, literature supports the fact that the rate of injuries sustained during CrossFit® training were similar to high intensity sports including gymnastics, powerlifting and weightlifting. It also concludes that injury rates in competitive contact sports such as rugby are higher than that reported in CrossFit® (Hak et al., 2013). According to Klimek, Ashbeck, Brook and Durall (2018), CrossFit® injury rates were comparable or lower than the injury rates in distance running, track and field, gymnastics and military training. In 2010, the U.S. military conducted its own investigation into CrossFit® as a training tool for its soldiers and reported that CrossFit® training could improve the functional capacity of soldiers (Paine, Uptgraft and Wylie, 2010).

Epidemiological studies on runners have reported injury incidence ranging from 19.4% to 79.3% (Van Gent, Siem, Van Middelkoop, Van Os, Bierma-Zeinstra and Koes, 2007). In comparison, studies on CrossFit® athletes have reported injury incidence rates ranging from approximately 19.4% to 73.5% (Tibana and Sousa, 2018). Although findings suggest that CrossFit® training was comparable to other sports that also focus on high-intensity exercises, it seems that those within their first year of training, as well as those who engage in this training modality less than 3 days per week, and/or participate in less than 3 workouts per week, are at a greater risk for injuries (Feito et al., 2018).

According to Meyer et al. (2017), Mehrab et al. (2017) and other studies, rates for CrossFit® training injuries were consistent with those rates for injuries encountered in other fitness routines (Costa et al., 2019; Aasa, Svartholm, Andersson and Berglund, 2017; Summit et al., 2016). In terms of health outcomes and body injuries, CrossFit® was thus comparable to other sports that focus on high intensity exercise routines (Meyer et al., 2017; Tafuri, Notarnicola, Monno, Ferretti and Moretti, 2016).

Klimek et al. (2018) reported that injury incidence in programs like CrossFit® were comparable and even lower than popular physical exercise practices and even traditional strength training.

CHAPTER 3 - METHODOLOGY

3.1 Introduction

This chapter aimed to describe the methods in which this study was performed and provide details on participant selection, piloting the study, survey development, ethical considerations, data collection and analysis.

The purpose of the study was to establish the injury rate associated with CrossFit® participation and to ascertain the risk factors contributing to these injuries so as to gain a better perspective of the sport within a South African context.

3.2 Study Design

This study was a descriptive cross-sectional survey-based study. The intentions of the study were to determine the injury rates in CrossFit® athletes within Johannesburg, South Africa, as well as the risk factors that lead to injuries. The survey contained questions on demographical information, details about sustained injuries as well as which medical practitioners were consulted for each injury.

3.3 Research Method

The survey was based on existing literature by Mehrab et al. (2017) and adapted with the assistance of Mrs. Jaclyn De Klerk at the University of Johannesburg's Statistical Consulting Agency (STATKON). The survey was conducted electronically using QuestionPro 2020 Survey Software.

3.3.1 Participant recruitment

The possible participants of the survey were male and female CrossFit® athletes training at a registered CrossFit® Gymnasium within Johannesburg and were 18 years of age or older.

Gymnasium owners were contacted via email containing the permission letter (Appendix A) and information letter (Appendix B) and asked to take part in the study. Those gymnasiums that responded and showed an interest in participating, received an additional email. The second email contained the information letter (Appendix B), consent form (Appendix C) and a link to the online survey (https://crossfit-injuries.questionpro.com/) (Appendix D) which were then sent to all active members on each gymnasium's database. The link was live from the 2nd of June 2020 to the 27th of July 2020.

Participants were informed in the information letter (Appendix B) and consent form (Appendix C) that by clicking on the link they were consenting to taking part in the online survey. In order to take part in the study each participant needed to meet the inclusion criteria of the study.

3.3.2 Inclusion criteria

The inclusion criteria required that each participant be:

1. Training at a registered CrossFit® gymnasium in Johannesburg, Gauteng.
2. 18 years of age or older.

The survey started off with these two criteria as questions. If a participant selected "no" to either question they were redirected to a separate page stating that they were not allowed to take part in the study.

3.3.3 Sample selection and size

A list of registered CrossFit® gymnasiums within Johannesburg was compiled using the CrossFit® main site. This provided a list of 29 gymnasium names and had direct links to each gymnasium's web page and provided all the contact details needed for every gymnasium including their email addresses. The resulting list of 29 gymnasiums were all contacted via email, containing both the permission and information letters (Appendix A and B). Of the 29 gymnasiums, 21 responded that they were interested in participating in the study. Of the remaining list, 7 gymnasiums declined to take part and 1 did not respond. The list of interested gymnasiums were then sent a second email containing the information letter (Appendix B), consent form (Appendix C) and a link to the online survey (Appendix D). This second email was then distributed by the participating gymnasiums and sent to all their members.

3.4 Preparation of Data Collection

This is before the survey could be distributed, the research required clearance from the Faculty Higher Degrees Committee (HDC) (number: HDC-01-08-2020) (Appendix E) and the Faculty Research Ethics Committee (REC) (ethics clearance number: REC-453-2020) (Appendix F).

Once the necessary clearance was received, the survey was distributed to every gymnasium on the list that agreed to take part in the research. The survey was then distributed to athletes via the participating gymnasiums' databases.

3.4.1 Survey development

The survey was based on an existing study by Mehrab et al. (2017), involving CrossFit® athletes in the Netherlands. The author was contacted via email and permission to use and adapt the survey was requested, to which the author consented. The final survey was then adapted from the Dutch study and developed with the help of Mrs. Jaclyn De Klerk of the Statistical Consulting Agency (STATKON) at the University of Johannesburg.

Once the survey head been developed and finalised, STATKON was commissioned to finalise the design and coding of the survey. The survey was emailed back to the researcher for final approval and testing. Corrections were made to ensure the survey functioned smoothly, was easy to understand, saved data correctly and that filter questions functioned as intended.

3.4.2 Survey content

The survey (Appendix D) started with 2 filter questions pertaining to the inclusion criteria and the rest of the survey was further divided into 3 sections: Section A, Section B and Section C. Section A involved demographic questions such as age and gender. Section B and C were questions relating to injury data and risk factors

Upon opening the survey, participants had to meet the inclusion criteria before being able to proceed with the rest of the survey. This meant confirming that participants were training CrossFit® at a registered gymnasium and were over 18 years of age. Any participant who failed to meet these criteria was redirected to a separate page stating that they were unable to take part in the study and were thanked for their time.

In each section, participants were asked to complete multiple-choice questions, answered by selecting the options that were most applicable for each question. If participants felt that none of the options were applicable, they were able to select the 'other' option and specify their answer by typing it into the text box provided.

Due to the design of the survey, all responses were completely anonymous and could not be traced back to any of the participants. It was also clearly stated, before starting the survey, that participants were free to withdraw any time before submitting their final responses. The survey took 2 to 5 minutes to complete and once the participant submitted their final responses they were thanked for their time and contribution. Consent was given by clicking on the link and participating in the study. This was clearly stated and explained in the information letter (Appendix B).

3.4.3 Pretesting the survey

Before the survey had final approval, pretesting was done by using a pilot survey. This pilot survey was completed by the researcher and 10 other CrossFit® athletes who met the inclusion criteria. This was to ensure that all the questions asked were unambiguous, easily understandable, that instructions were clear and were easy to follow, that all spelling, grammar and punctuation were correct, and that the process concluded the survey effectively. Results from the pilot survey were excluded from the final data analysis. To ensure the integrity of the study, the survey link for the pilot study as well as the final study, allowed participants to submit their results only once. Any amendments that may have been highlighted, were attended to prior to sending out the final survey.

3.5 Data Collection

Data was collected by means of an online survey hosted by STATKON using QuestionPro 2020 Survey Software.

The list of 21 interested gymnasiums received a second email containing the information letter (Appendix B), consent form (Appendix C) and a link to the online survey (Appendix D). This second email was then distributed by the 21 participating gymnasiums and sent to all their active members on their databases. Participants in this study amounted to a total of 250 valid responses with each participant receiving the above-mentioned appendixes.

Participant were informed in the information letter (Appendix B) and consent form (Appendix C) that by clicking on the link (Appendix D) provided within the email they were consenting to taking part in the online survey. Participants who clicked on the link were redirected to the STATKON-based website containing the survey where it could be completed anonymously. In order to take part in the study each participant needed to meet the inclusion criteria of the study in the form of two questions at the start of the survey.

Online surveys are a well-established concept and thus offered a user-friendly method of data collection for both the participants and researcher alike in this study. The cost-effective aspect of the survey made it ideal for collecting data and no travel was needed to conduct the study. The nature of the study ensured the elimination of interviewer bias, allowing participants the opportunity to be more honest in their responses (Statpac Inc, 2017). Other advantages included low costs, less time needed and more accurate results culminating in a faster and less-complicated method of data collection (Smart Survey, 2016). The self-administered nature of the survey meant that participants could complete the survey at a time that would be most convenient to them. Anonymity and confidentiality were ensured, encouraging honest participant responses, preventing bias and allowing for reliable data. The right to withdrawal from the study at any point prior to submission was emphasized throughout the research. Consent was obtained from all participants taking part in this study.

Disadvantages of a self-administered online survey included a lower response rate compared to in-person interviews as well as not having control of who answers the survey (Statpac Inc, 2017). However, the advantages outweighed the disadvantages making it an appropriate design for this study. This risk was also minimised by only sending emails to registered CrossFit® gymnasiums and their membership databases.

The response data was directly interpreted by STATKON and ensured confidentiality.

3.6 Data Analysis

3.6.1 Statistical procedure

The data from completed surveys were collected and statistically analysed by Mrs Jaclyn De Klerk, a qualified statistician of the Statistical Consulting Agency (STATKON) at the University of Johannesburg. The program used to analyse the data was IBM SPSS version 26. The data analysis consisted of descriptive statistics, frequencies and custom tables. To determine the number of times each answer was supplied, frequencies describing the categorical data were used. The descriptive statistics used methods such as mean, median, interquartile range, standard deviation, minimum and maximum to illustrate the continuous data. For questions involving multiple responses, custom tables were used to illustrate the data that was obtained.

The collected data was then placed into graphs and tables for illustration. A full discussion and description of the findings of the data analysis can be found in chapter 4.

3.7 Reliability and Validity

3.7.1 Validity

In order to ensure validity, the study and its results needed to meet all the necessary requirements of the scientific research method (Shuttleworth, 2008). This survey focussed on the incidence of injuries and potential risk factors related to CrossFit® participation in

Johannesburg, South Africa. The survey contained questions on demographical information, details about sustained injuries, training history, as well as which medical practitioners were consulted for each injury. Although more CrossFit®-related research has emerged since 2013, none of these studies have been conducted in South Africa. Therefore, previous studies done abroad, relating to injury rates and risk factors in CrossFit® participants, were used during the design and development of the survey to compare results between similar studies.

Validity was ensured by means of four types of validity as discussed below.

A. Face validity

Face validity is a measure of how representative a research study is at face value and whether it appears to be a good project (Shulttleworth, 2008). This was ensured by sending emails to registered gymnasiums which were then forwarded to their active membership databases. These emails contained the information letter (Appendix B), consent form (Appendix C) as well as a link to the online survey (Appendix D). The information letter highlighted the purpose of the study and how to complete the survey. It was also stated that participation was voluntary, anonymity was guaranteed and that participants were free to withdraw from the study at any time prior to submission. The consent form explained that by continuing and clicking on the link provided, they agreed to consent to the research. Participants who were interested in participating in the study would click on the link provided, granting access to the online survey created by STATKON. Upon completion of the survey, participants selected the "*submit*" option to end the survey. Answers were then saved, and participants were thanked for their time. Once submitted, no answers could be traced back to any participants ensuring complete anonymity in order to maintain face validity.

B. Content validity

Content validity was ensured in this study by conducting thorough research on relevant literature and previous similar studies relating to CrossFit® related injuries. The survey was based on an existing study by Mehrab et al (2017) and further developed with the help of Ms Jaclyn De Klerk, a qualified statistician. The review and editing of the survey were regularly moderated by the researcher, supervisor and statistician before the final survey was presented to REC. The Department of Chiropractic, HDC, REC and the University of Johannesburg all received the survey for validation of the suitability, descriptive ability and accuracy. Once the questions had been finalised and approved, STATKON was tasked with the final design and coding of the survey for the website.

C. Internal validity

Development of the survey was based on extensive literature review of relevant literature and previous similar studies relating to CrossFit® related injuries. The online survey was also pretested by the researcher, supervisor and statistician. This was done to ensure internal validity before being sent to participant. This ensured that all the questions asked were unambiguous, easily understandable, that instructions were clear and were easy to follow, that all spelling, grammar and punctuation were correct, and that the process concluded the survey effectively.

D. External validity

External validity refers to the ability to generalise based on the results obtained in a specific study (Shuttleworth, 2008). The sample was formed by participants of age 18 years or older, training at registered CrossFit® gymnasiums within Johannesburg. The sample is representative of the population that were willing to participate in the study. The results received were analysed based on the participants' experiences with regards to CrossFit® related injuries, training history, injuries prior to CrossFit® and health practitioners consulted for each injury. Therefore, results cannot be generalised to the entire population of CrossFit® athlete, neither in Johannesburg nor across South Africa. The results can however possibly generate new information for coaches and health professionals that could be added to the currently scarce body of research available on CrossFit® related injury rates and potential risk factors.

3.8 Ethical Considerations

Participation in this study was on a volunteer basis and all participants were informed of the purpose of the study by means of an email containing the information letter (Appendix B) and consent from (Appendix C) specific to this study. The information letter outlined the purpose of the study and participants were assured that the entire process would be anonymous and confidential. Participants were free to withdraw from the study at any time prior to submission of results. However, once the survey was submitted the results could not be removed or traced back to any participants due to the anonymity of the study. Consent was explained in the consent form and clearly stated that by clicking the link to the online survey (Appendix D) and taking part in the study, consent was given to the research. Any further questions regarding the study and consent could be obtained from the information letter or directed to the researcher via information provided. No personal details were recorded at any point during the survey. Participants interested in the results of the study could contact the researcher directly.

To ensure that no plagiarism occurred in this study, an anit-plagiarism software called Turnitin was used and the resulting report provided (Appendix E).

CHAPTER 4 - RESULTS

4.1 Introduction

This chapter of the study presents the results of the data collected from the survey on the injury incidence and risk factors in CrossFit® athletes within Johannesburg.

Emails containing the link to the online survey were distributed to CrossFit® gymnasiums within Johannesburg. These emails were then distributed to participants via each gymnasium's databases. At the time of the survey's distribution, there were 29 registered CrossFit® gymnasiums in Johannesburg, 7 declined to take part in the study and 1 did not respond. The online survey was live for 8 weeks and the 21 participating gymnasiums produced 250 valid responses, all of which met the inclusion criteria. Due to the multiple response nature of the study, the number of responses varied between questions, therefore the number of responses were indicated by the (n) value for each question.

4.2 Demographic Information of the Sample Population

4.2.1 Age Distribution (n=189)

Table 4.1: Table indicating the age distribution of CrossFit® athletes

Age (Years)			
Min	**Max**	**Mean**	**Range**
18	71	33.5	53

The average age of the population of CrossFit® athletes that completed the survey was 33.5 years. The youngest participant was 18 years of age and the oldest was 71 years of age. This provided an age range of 53 years. The most common age was 32 years of age with 14 (5.6%) of the participants being this age.

4.2.2 Gender Distribution (n=250)

Table 4.2: Table indicating the gender distribution of CrossFit® athletes

Gender		
Male	125	50%
Female	125	50%
Total	250	100%

The gender distribution was equally shared between male and female participants with 50% males (n=125) and 50% females (n=125).

4.3 Training Information of the Sample Population

4.3.1 Time-elapsed participating in CrossFit® (n=250)

As shown in figure 4.1 below, 6.4% or 16 of the participants surveyed, had been doing CrossFit® for 6 months or less. 10.4% or 26 of the participants had been doing CrossFit® between 6 and 12 months. 16.8% or 42 of the participants had been doing CrossFit® for 1 to 2 years. 41.6% or 104 of the participants had been doing CrossFit® for 2 to 5 years. 24.8% or 62 of the participants had been doing CrossFit® for more than 5 years.

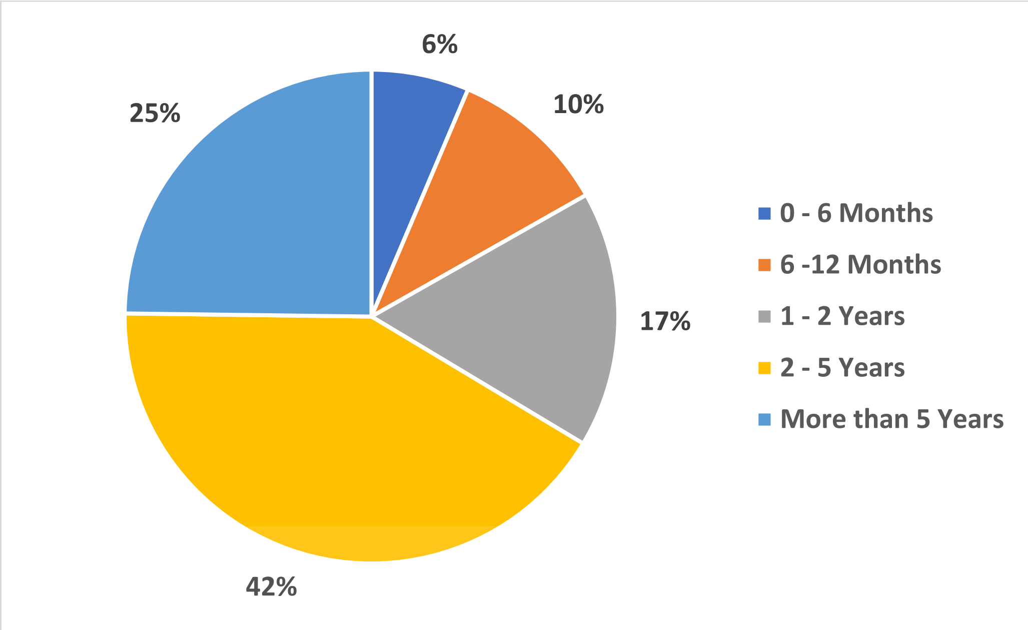

Figure 4.1: Pie chart indicating the elapsed time of participation in CrossFit® (n=250)

4.3.2 Beginners Program (n=250)

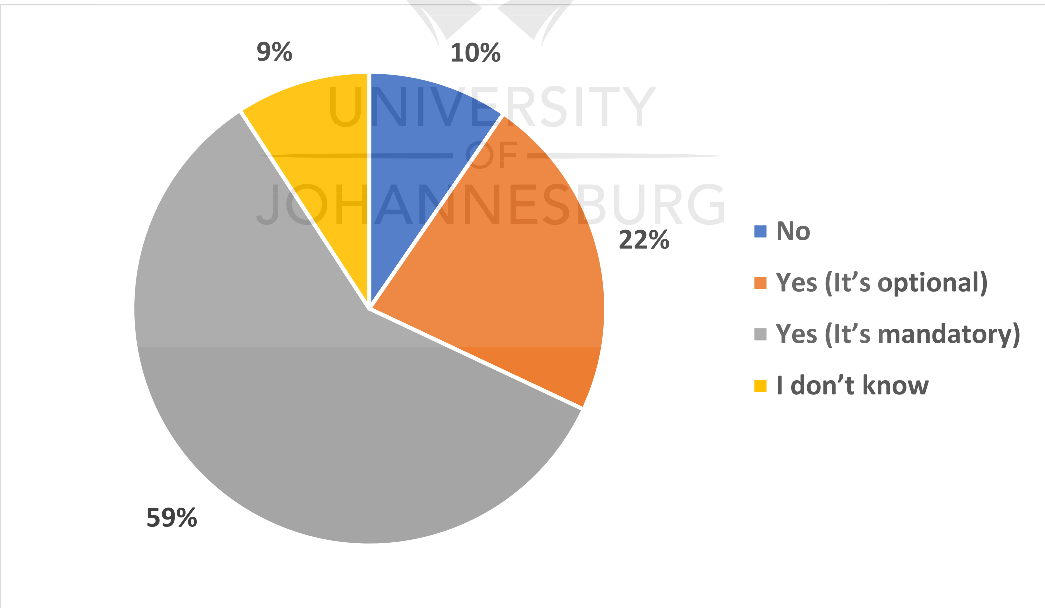

Figure 4.2: Pie chart indicating if gymnasiums provide a beginner's program (n=250)

As shown in figure 4.2 above, 9.6% or 24 of the participants surveyed stated that their gymnasium does not provide a beginner's program. 22.4% or 56 participants stated that their gymnasium does provide a beginner's program however it is optional. 58.8% or 147 participants stated that their gymnasium does provide a beginner's program and participation is mandatory for all members new to CrossFit®. 9.2% or 23 participants stated that they were not sure whether their gymnasiums provided a beginner's program.

4.3.3 Days per week participating in CrossFit® (n=250)

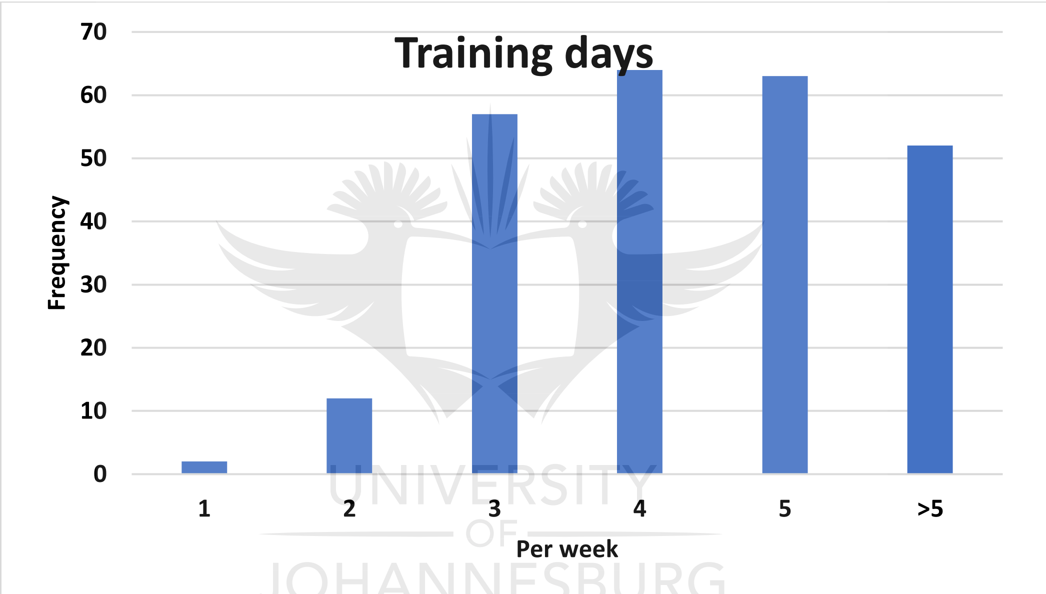

Figure 4.3: Bar graph indicating number of training days per week (n=250)

As shown in figure 4.3 above, 4.8% or 12 participants stated that they trained CrossFit® twice a week. 22.8% or 57 participants stated that they trained CrossFit® 3 days a week. 25.6% or 64 participants stated that they trained CrossFit® 4 days a week. 25.2% or 63 participants stated that they trained CrossFit® 5 days a week. 20.8% or 52 participants stated that they trained CrossFit® more than 5 days a week.

4.3.4 Multiple training sessions per day (n=249)

As seen in table 4.3 below, 14.5% or 36 participants stated that they trained CrossFit® multiple times per day. 85.5% or 213 participants stated that they only trained CrossFit® once per day.

Table 4.3: Table indicating the number of participants who train multiple times per day

	Frequency	Percent
Yes	36	14.5
No	213	85.5
Total	249	100

4.3.5 Average rest days per week (n=250)

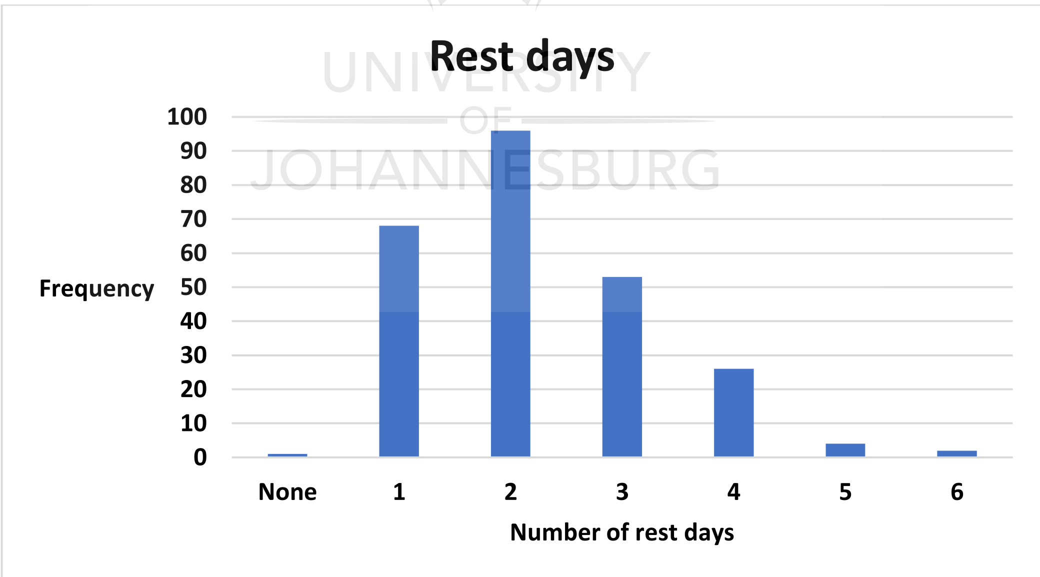

Figure 4.4: Bar graph indicating the number or rest days taken by participants per week (n=250)

As shown in figure 4.4 above, 0.4% or 1 participant stated that they did not take any rest days per week. 27.2% or 68 participants stated that they took 1 rest day on average per week. 38.4% or 96 participants stated that they took 2 rest days on average per week. 21.2% or 53 participants stated that they took 3 rest days on average per week. 10.4% or 26 participants stated that they took 4 rest days on average per week. 1.6% or 4 participants stated that they took 5 rest days on average per week. 0.8% or 2 participants stated that they took 6 rest days on average per week.

4.3.6 Average number of strength training sessions per week (n=247)

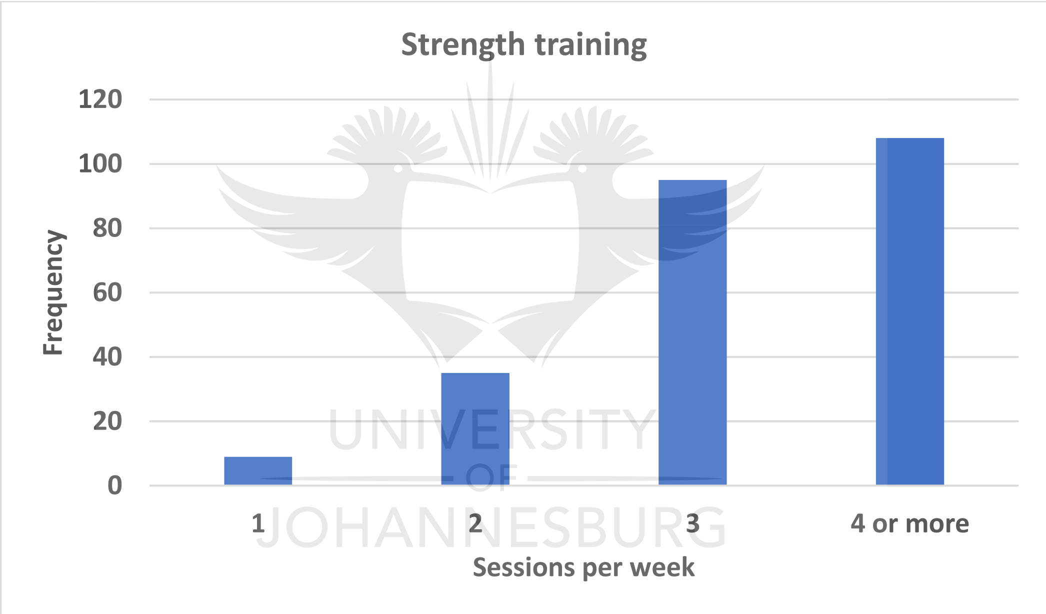

Figure 4.5: Bar graph indicating the average number of strength training sessions per week (n=247)

As shown in figure 4.5 above, 3.6% or 9 participants stated that they participated in 1 strength training session per week on average. 14.2% or 35 participants stated that they participated in 2 strength training sessions per week on average. 38.5% or 95 participants stated that they participated in 3 strength training sessions per week on average. The majority and remaining 43.7% or 108 participants stated that they participated in 4 or more strength training sessions per week on average.

4.3.7 Average technique/skill training sessions per week (n=248)

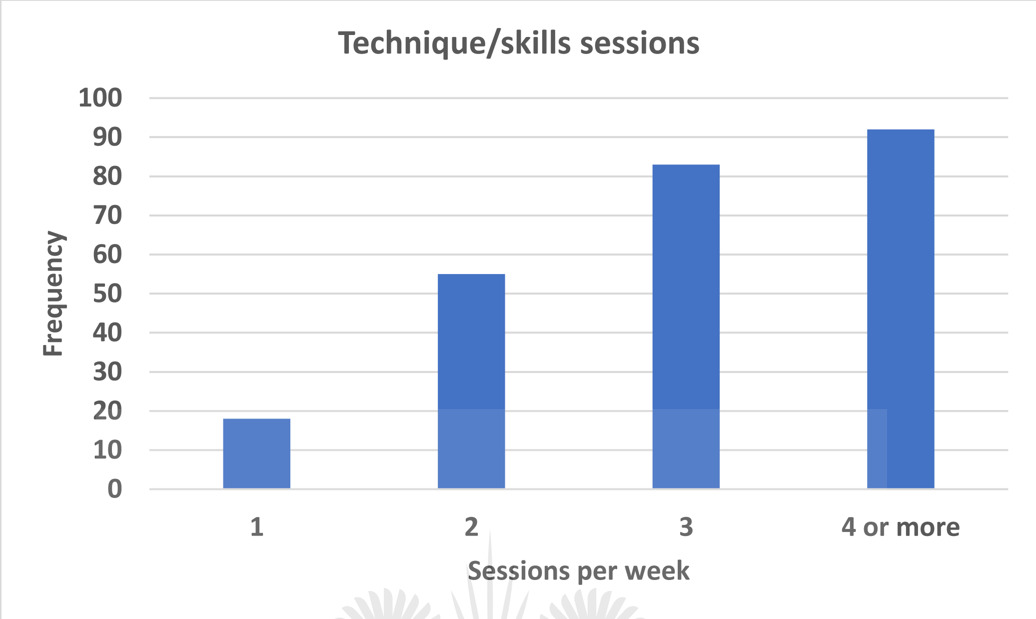

Figure 4.6: Bar graph indicating the average number of technique/skill training sessions per week (n=248)

As shown in figure 4.6 above, of the valid responses, 7.3% or 18 participants stated that they did technique/skill training 1 day per week on average. 22.2% or 55 participants stated that they did technique/skill training 2 days a week on average. 33.5% or 83 participants stated that they did technique/skill training 3 days a week on average. The majority and remaining 37.1% or 92 participants stated that they did technique/skill training 4 or more days a week on average.

4.3.8 Warm up structure (n=1061)

Table 4.4: Table indicating warm up structure of CrossFit® classes

Warm up routine	Responses	Percent	Percent of cases
Full body exercise (running/jump rope/rowing)	212	20,0	85,5
Static stretching	121	11,4	48,8
Dynamic stretching	159	15,0	64,1
Movement specific exercises (e.g. squats before a squat workout)	213	20,1	85,9
Technique training drills (practicing skills from weightlifting/gymnastics)	173	16,3	69,8
Gradual warm-up to workout weight	181	17,1	73,0
No warming up	2	0,2	0,8
Total	1061	100,0	427,8

As seen in table 4.4 above, of the valid responses, 85.9% or 213 participants and 85.5% or 212 participants stated that their warmup included full body exercise and movement specific exercise, respectively. Gradually warming up towards the weight that would be used in the workout was included in warmup of 73% or 181 of participants' training sessions. Technique training drills were used in warmup by 69.8% or 173 participants. Dynamic stretching was used in warmup by 64.1% or 159 participants. Static stretching was used in warmup by 48.8% or 121 participants. Only 2 participants stated that they did not use any form of warm up.

4.3.9 Average mobility training participation per week (n=246)

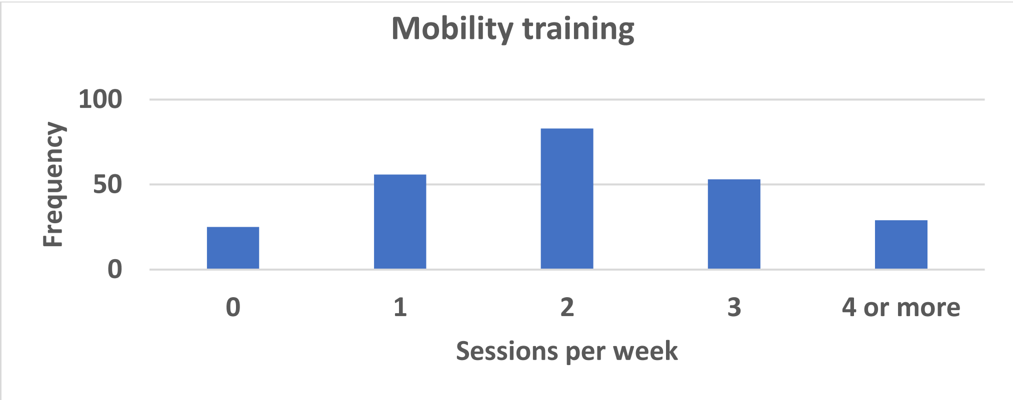

Figure 4.7: Bar graph indicating the average number of mobility training sessions per week (n=246)

As shown in figure 4.7 above, of the valid responses 10.2% or 25 participants stated that they did not take part in any mobility training. 22.8% or 56 participants stated that they took part in at least one mobility training session on average per week. 33.7% or 83 participants stated that they took part in two mobility training sessions per week. 21.5% or 53 participants stated that they took part in three mobility training sessions per week. The remaining 11.8% or 29 participants stated that they took part in four or more mobility training sessions per week.

4.3.10 Participation in sports other than CrossFit® (n=250)

Table 4.5: Table indicating participation in sports other than CrossFit®

Other sports	Frequency	Percentage
Yes	107	42,8
No	143	57,2
Total	250	100,0

As seen in table 4.5 above, 42.8% or 107 participants stated that they were involved in sporting activities outside of CrossFit®. The remaining 57.2% or 143 participants were not. Running, cycling and swimming were the most popular non-CrossFit® activities mentioned, making up 74.7% of listed outside activities. Out of this 74.7%, running accounted for 41.1% of non-CrossFit® activities.

4.4 Injury data of Sample Population

4.4.1 Number of injuries sustained since starting CrossFit® (n=250)

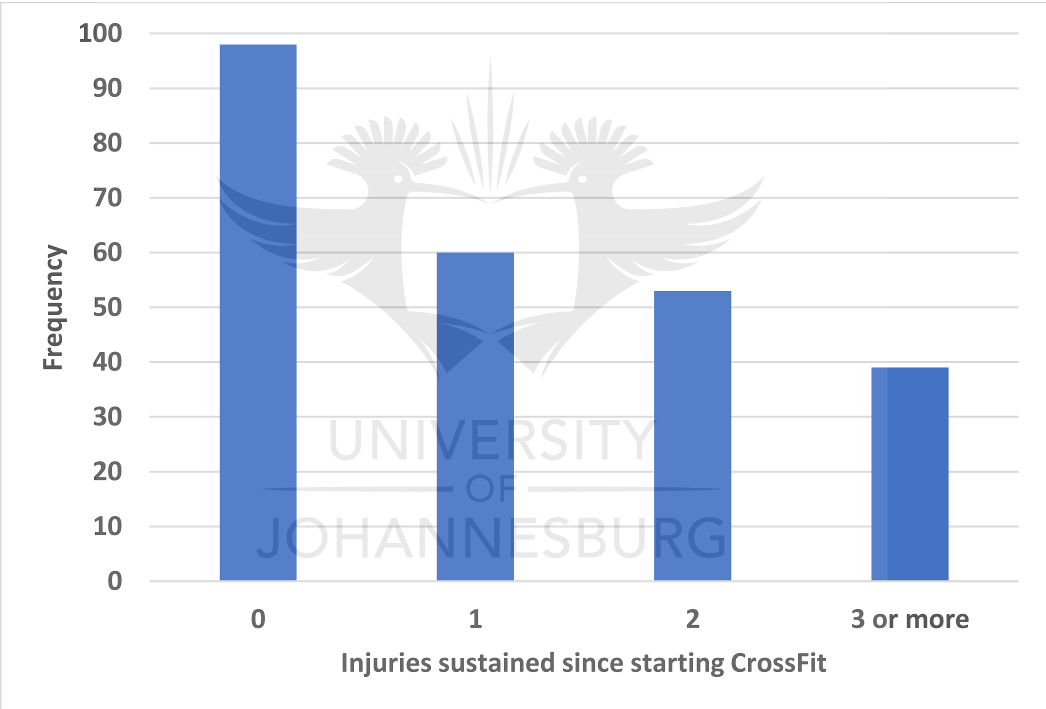

Figure 4.8: Bar graph indicating the number of injuries sustained since starting CrossFit® (n=250)

As shown in figure 4.8 above, 39.2% or 98 of the participants surveyed, stated that they had not sustained any CrossFit® related injuries since starting CrossFit®. Of the remaining 60.8%, 24 percent or 60 participants had sustained one injury since starting CrossFit®. 21.2% or 53 participants had sustained two injuries since starting CrossFit® and the remaining 15.6% or 39 participants had reported sustaining 3 or more injuries since starting CrossFit®.

4.4.2 Injury regions (n=269)

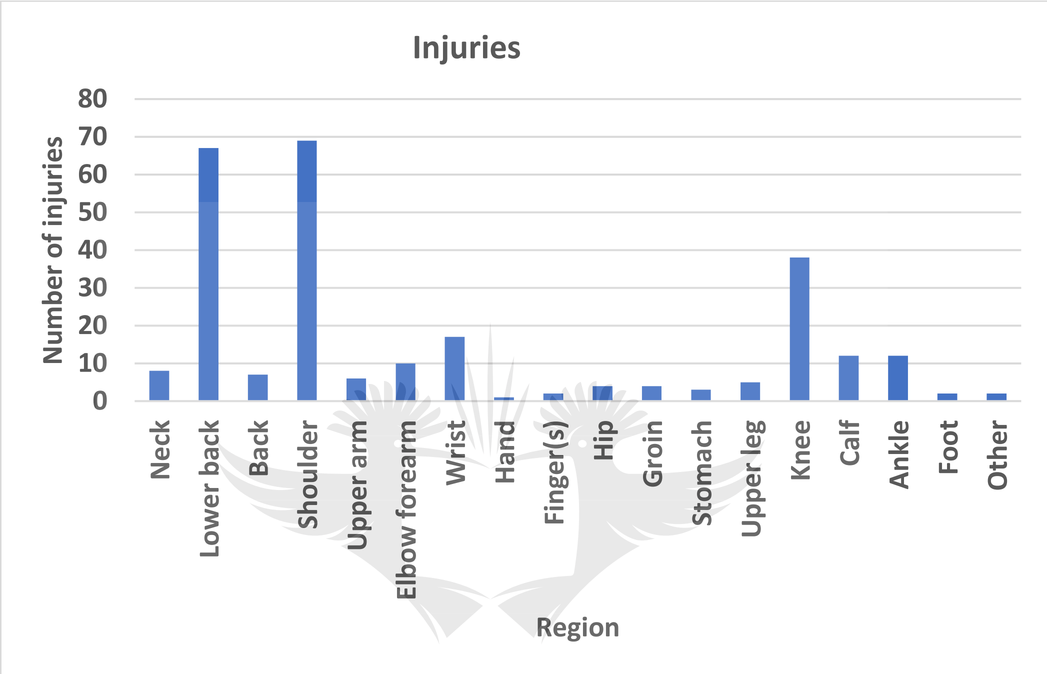

Figure 4.9: Bar graph indicating the number and region of the most significant injuries (n=296)

As shown in figure 4.9 above, of the 269 injuries that were reported, the most prevalent were shoulder, low back and knee injuries. These 3 regions made up almost 65% of all the injuries listed. As seen in figure 4.9, 25.7% or 69 injuries occurred in the shoulders. The lower back accounted for 24.9% or 67 injuries. 14.1% or 38 injuries occurred in the knees. Seventeen wrist injuries (6.3%) and 24 calf and ankle injuries (9%) were reported. The two injuries reported as "Other" were injuries to the Gluteal muscles.

4.4.3 Injury timing (average in years) (n=132)

Table 4.6: Table indicating the participation time in CrossFit® prior to sustaining an injury

Mean	Median	Mode	Std. Deviation	Minimum	Maximum
2,1472	2,0000	2,00	1,31674	0,06	6,83

As seen in table 4.6 above, the average time of participation in CrossFit® training prior to sustaining a CrossFit® related injury was 2.1 years with a standard deviation of 1.3 years. Of the 132 participants that reported injuries, the shortest time of participation before sustaining an injury was 3 weeks and the longest was 6.83 years. The median and mode were 2 years each.

4.4.4 Abstaining from training (n=247)

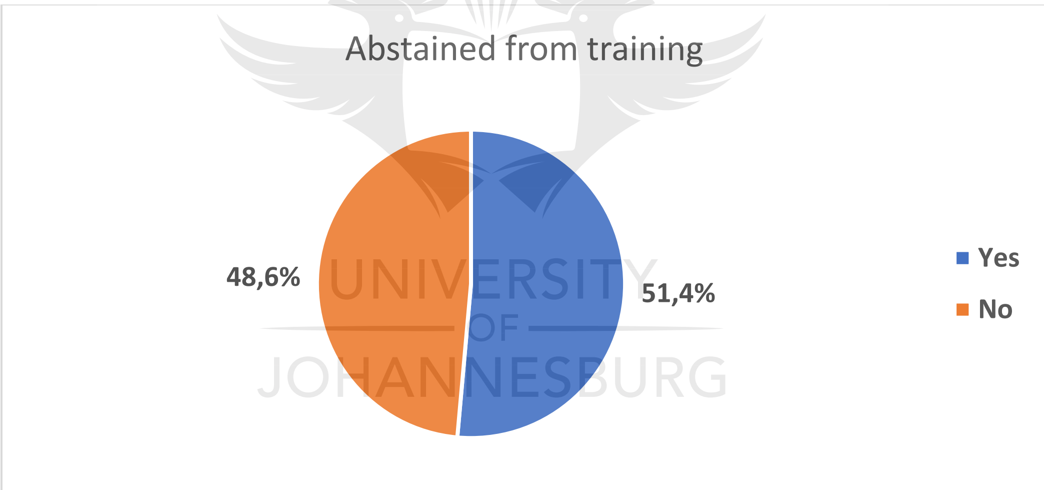

Figure 4.10: Pie chart indicating whether participants abstained from training due to injury (n=247)

As shown in figure 4.10 above, of those injuries reported, 51.4% or 127 of the listed injuries led to participants abstaining from training. In 48.6% or 120 of the listed injuries, participants did not abstain from training.

4.4.5 Injury diagnoses (n=296)

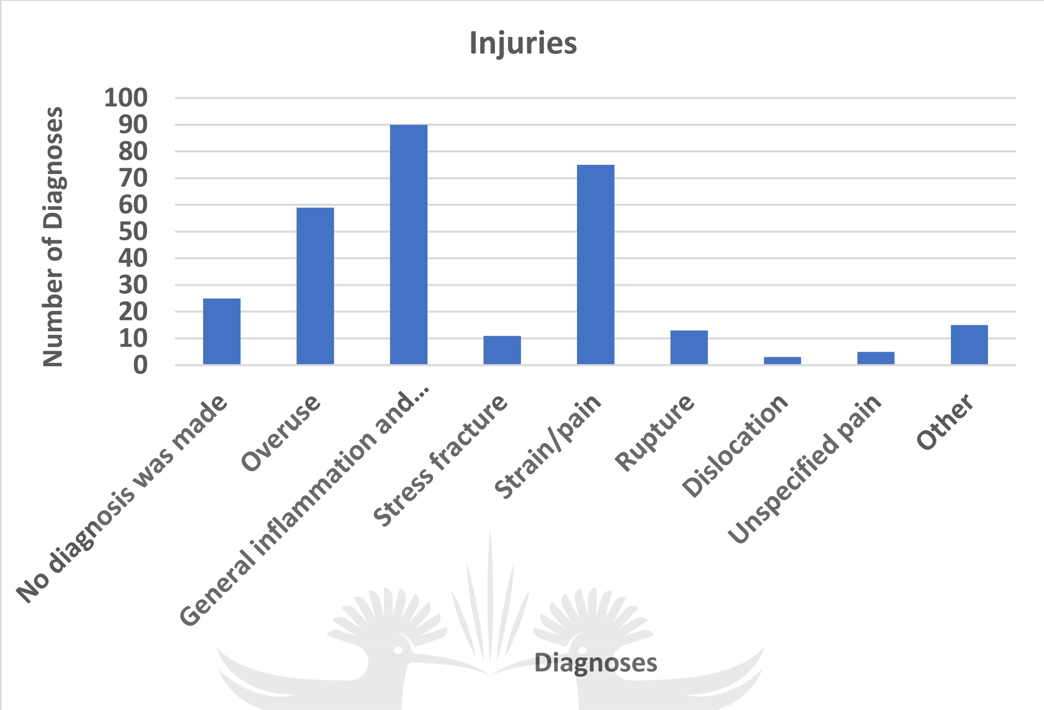

Figure 4.11: Bar graph indicating the types of diagnoses and number of diagnoses (n=296)

As shown in figure 4.11 above, 8.4% of injuries were not diagnosed. Of those that were diagnosed, 30.4% or 90 injuries were diagnosed as general inflammation and pain. 25.3% or 75 injuries were diagnosed as strain/sprain. 20% or 59 injuries were diagnosed as overuse injuries. 5% of injuries did not match the categories available and were reported as “other”. Listed among these other injuries were two herniated intervertebral discs, two pinched spinal nerves, two bone fractures due to falling equipment, hip impingement, pre-existing joint arthroses and a knee contusion. 4.4% or 13 injuries were diagnosed as ruptures. 3.7% or 11 injuries were diagnosed as stress fractures. The remaining 2.7% of injuries diagnosed were unspecified pain (1.7%) and dislocations (1%).

4.4.6 Discomfort prior to injury (n=245)

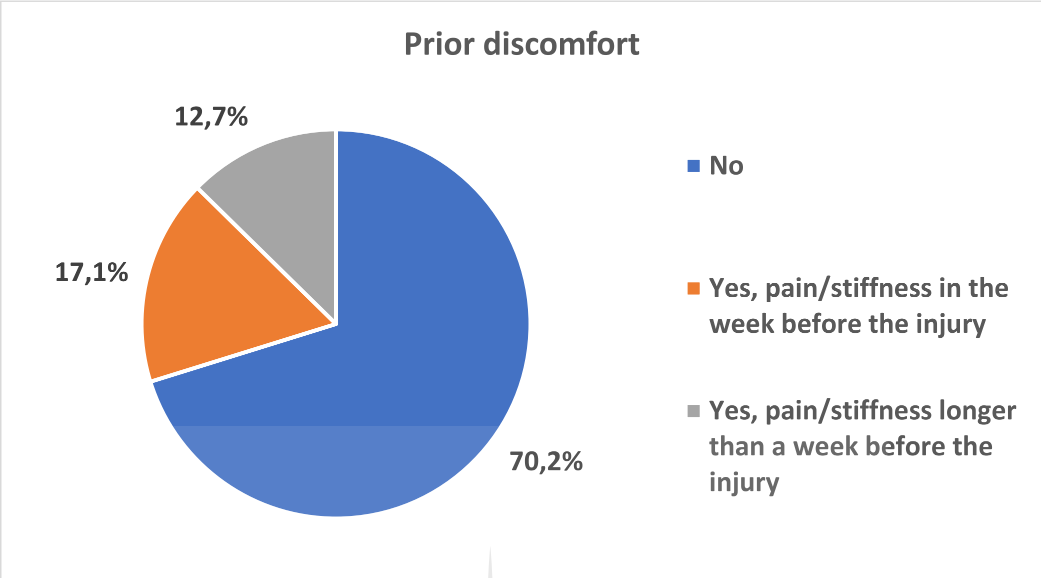

Figure 4.12: Pie chart indicating if any discomfort was felt in the injury region prior to injury (n=245)

As depicted in figure 4.12 above, of 70.2% (172) of injuries listed, participants reported experiencing no discomfort in the injured regions prior to injury. In 17.1% or 42 of the reported injuries, participants experienced discomfort in the injured regions during the week leading up to the injury. The remaining 12.7% or 31 of the reported injuries, participants experienced discomfort in the injured regions for longer than a week prior to injury.

4.4.7 Injury activity (n=266)

As depicted in figure 4.13 below, the majority of injuries occurred during the Workout of the Day (WODs) accounting for 44% or 117 of the injuries listed. 30.5% or 81 of the listed injuries occurred during strength training. 9.4% or 25 of the listed injuries occurred during running related activities. 6% or 16 of the injuries listed occurred during technique training. For the remaining 10.2% or 27 of the listed injuries, the activity during which the injury occurred could not be recalled.

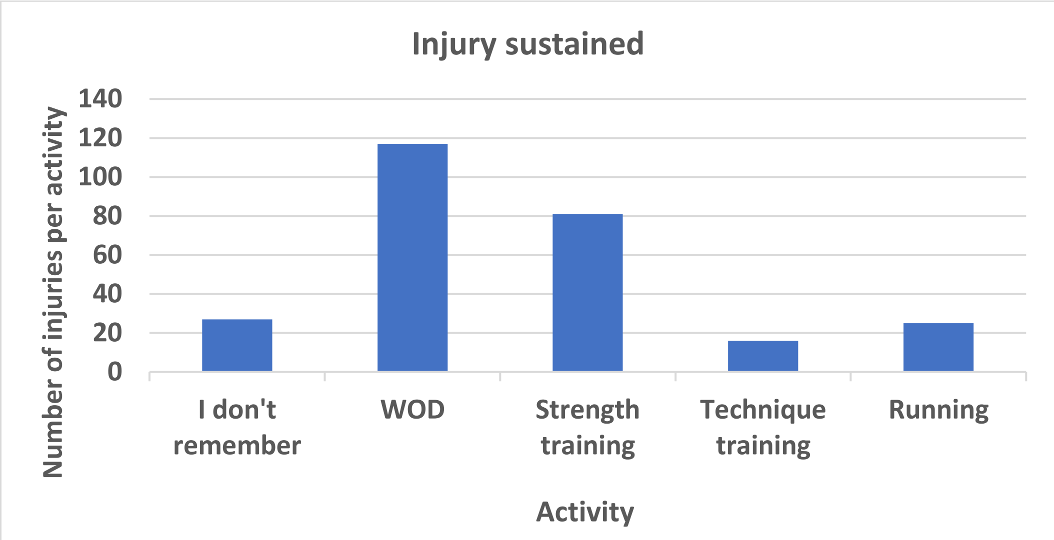

Figure 4.13: Bar graph indicating the number of injuries sustained in each activity (n=266)

4.4.8 Injury mechanism (n=329)

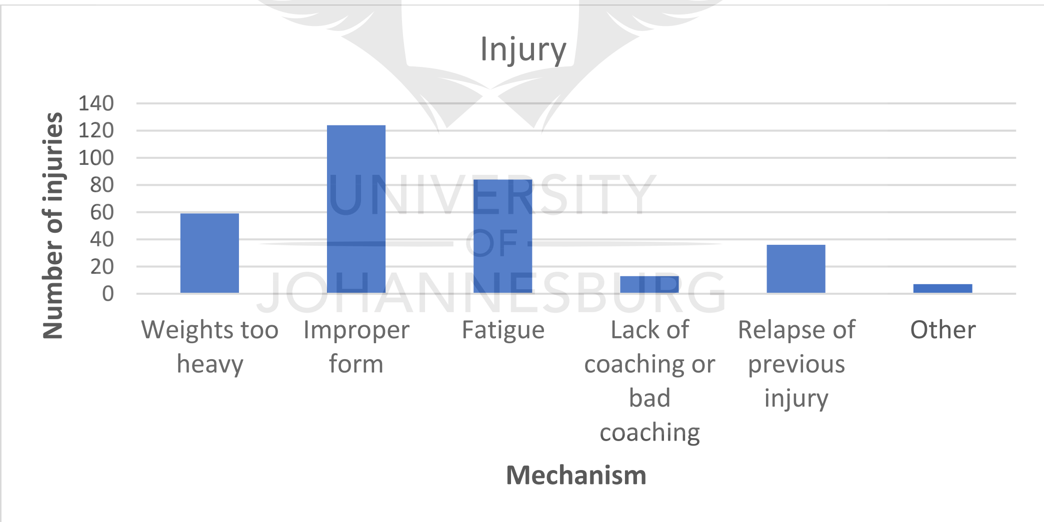

Figure 4.14: Bar graph indicating the mechanism of injury (n=329)

As depicted in figure 4.14 above, of all valid responses relating to mechanism of injury, improper form accounted for 38.4% or 124 of the injuries listed. Fatigue was attributed to 26% or 84 of the injuries listed. Weights that were too heavy was attributed as causing 18.3% or 59 of the injuries listed. Relapse of prior injuries accounted for 11.1% or 36 of the listed injuries. 4% or 13 injuries were attributed to bad coaching or a lack thereof. The remaining seven injuries (2.2%) were reported as other, with two injuries occurring due to loss of concentration and one injury believed to be due to post-partum abdominal muscle weakness. No further details were provided for 4 out of the 7 "other" injuries.

4.4.9 Health practitioner that was consulted and number of injuries (n=315)

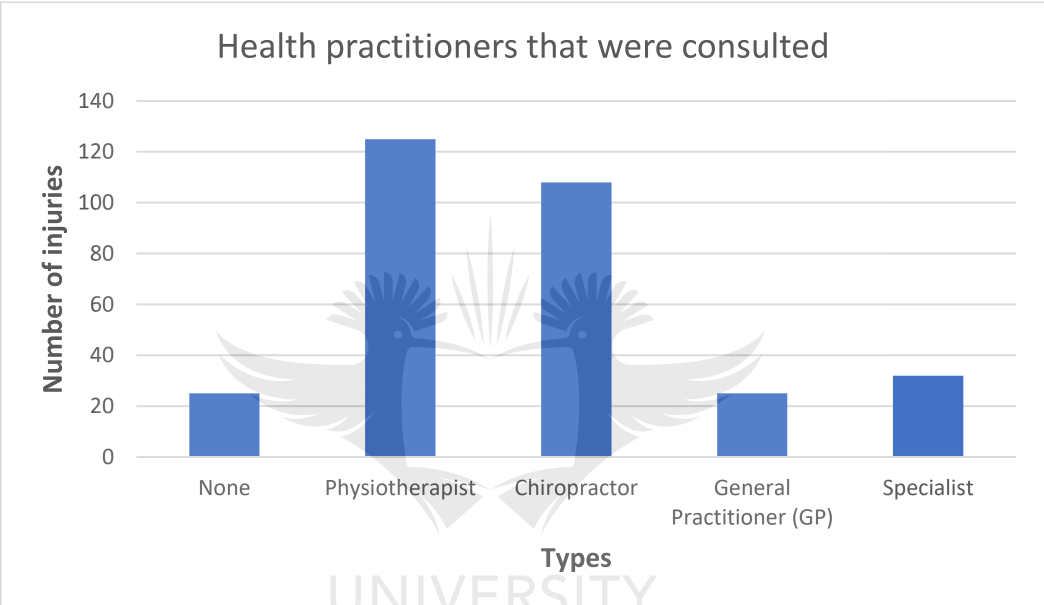

Figure 4.15: Bar graph indicating the number of injuries consulted on by health practitioners (n=315)

As shown in figure 4.15 above, physiotherapists and chiropractors were the most visited health professionals for CrossFit® related injuries. Of the reported injuries, physiotherapists were consulted for 39.7% of injuries with chiropractors being consulted for 34.3% of injuries. 10% of injuries were seen to by specialists and 8% were seen to by general practitioners. The remaining 8% of injuries were not consulted on by any health practitioner.

4.5 Cross Tabulations

4.5.1 Beginners program and number of injuries

Table 4.7: Table depicting the number of injuries in relation to participation in beginner's program

Beginners program		**Injuries**				**total**
		0	**1**	**2**	**3 or more**	
No and optional	Frequency	33	21	15	11	80
	Percentage	41,3%	26,3%	18,8%	13,8%	100,0%
Mandatory	Frequency	54	33	35	25	147
	Percentage	36,7%	22,4%	23,8%	17,0%	100,0%
Total	Frequency	87	54	50	36	227
	Percentage	38,3%	23,8%	22,0%	15,9%	100,0%
Pearson Chi-Square				**Value**	**Df**	**P value**
				1.539	3	.637

Data cross tabulations, as seen in table 4.7 above, were conducted to compare the significance of gymnasiums providing a beginner's program with the amount of injuries reported. Looking at the percentages, there seems to be little difference between the gymnasiums that have a mandatory beginner's program and those that do not. Both groups follow the same proportion of injuries as seen in figure 4.16 below.

To test for significance, a Pearson Chi-Square test was performed and produced a value of 1.539, 3 degrees of freedom (df) and Asymptotic Significance (P value) of 0.673. Due to the P value being more than 0.05, the significance of a beginner's program in relation to the amount of injuries sustained are considered to be of very low significance within this study.

However, more research is needed on this topic, preferably with a larger sample size of participants.

4.5.2 Gender and number of injuries

As seen in table 4.8 below, females have a lower number of injuries overall. Of those participants who reported not sustaining any injuries, females reported significantly less injuries than males. Of those participants who reported sustaining only one injury, females reported 3.2% higher than males. The inverse was true for the participants reporting two injuries with males reporting 2.4% more than females. Male participants reporting three or more injuries were 13.6% higher than females.

Table 4.8: Table depicting number of injuries in relation to males and females

		Number of injuries				**Total**
		0	**1**	**2**	**3 or more**	
Male	Frequency	41	28	28	28	125
	Percent	32,8%	22,4%	22,4%	22,4%	100,0%
Female	Frequency	57	32	25	11	125
	Percent	45,6%	25,6%	20,0%	8,8%	100,0%
Total	Frequency	98	60	53	39	250
	Percent	39,2%	24,0%	21,2%	15,6%	100,0%
				Value	**Df**	**P value**
Pearson Chi-Square				10.459	3	.015
Cramer's V				.205		.015

The test for significance using Pearson Chi-Square test produced a value of 10.459, 3 degrees of freedom and a P value of 0.15. Due to the low P value, the effect size was also calculated to determine the difference between males and females. This produced a Cramer's V value of .205, which translate to a medium effect size thus indicating a significant difference between males and females in relation to number of injuries. The difference in injury numbers can also be attributed to a variety of possible factors and will be discussed further in chapter 5.

4.5.3 Gender and injury regions

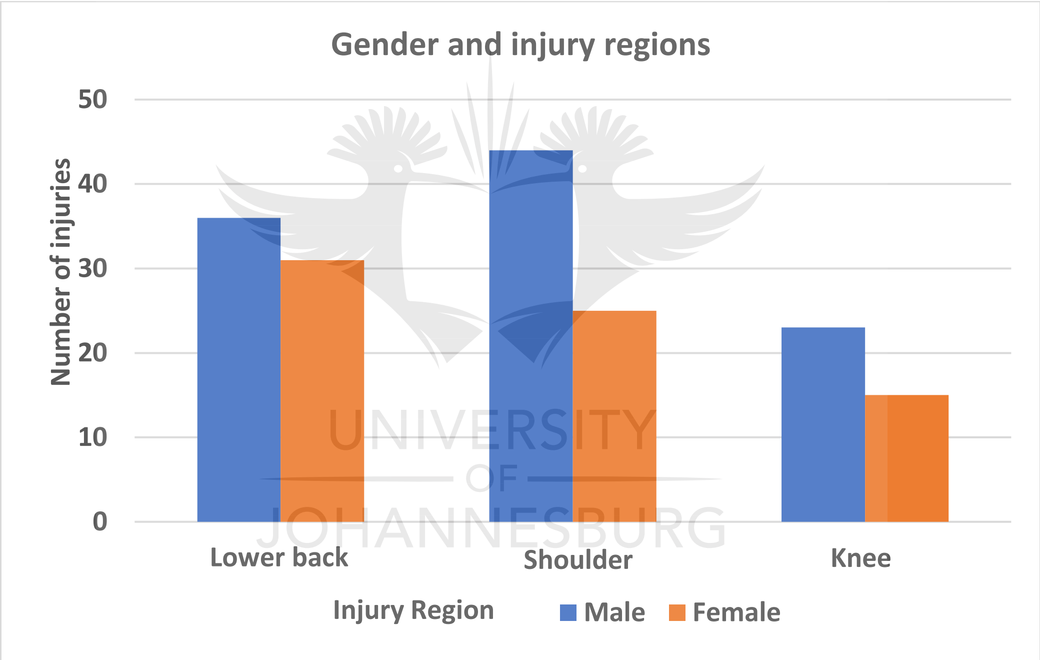

Figure 4.16: Bar graph depicting the number of injuries compared to males and female in the 3 most injured regions

As depicted in figure 4.16 above, males recorded a higher number of injuries than females in each of the three most affected body regions. However, when looking at these injury numbers relative to overall injuries reported (159 for males; 110 for females), females had a higher percentage of lower back injuries (28.2%) compared to males (22.6%).

Shoulder injuries accounted for 27.7% of total injuries in males and 22.7% in females. This showed a similar proportion of injuries between males and females, despite the fact that males reported significantly higher number of shoulder injuries than females as seen in figure 4.16 above.

Knee injuries accounted for 14.5% of total injuries in males and 13.6% in females. Once again, we see a similar proportion of injuries between males and females which is also reflected in the total number of knee injuries with males reporting a slightly higher number of knee injuries (23) than females (15).

4.5.4 Gender and abstaining from training due to injury

Table 4.9: Table depicting males and females in relation to abstaining from training due to injury

	Did you abstain from training?			
		Yes	**No**	**Total**
Male	Frequency	80	67	147
	Percentage	54,4%	45,6%	
Female	Frequency	47	53	100
	Percentage	47,0%	53,0%	
Total		127	120	247

As shown in table 4.9 above, males were more likely to abstain from training when injured, with 54.4% or 80 of the listed 147 injuries requiring male participants to abstain from training. Females were less likely to abstain from training when injured, with 47% or 47 of the listed 100 injuries requiring female participants to abstain from training. Interesting though this finding may be, the difference between males and females is marginal and does not offer appear to be very significant.

4.5.5 Gender and participation time prior to injury

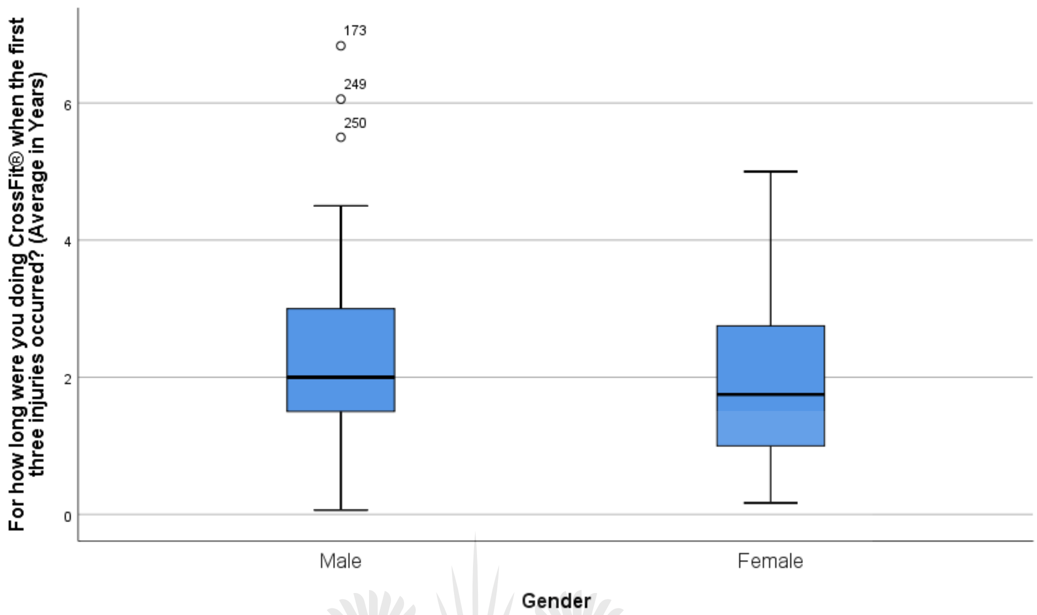

Figure 4.17: Box plot depicting the distribution between males and females in relation to participation time in CrossFit® prior to injury

To determine the distribution between males and females and their years of CrossFit® participation before injuries occurred, a test for normality was done. Because the group sizes were larger than 50 a Kolmogorov-Smirnov test was used. For males this produced a statistic value of 0.143, 73 degrees of freedom and a p-value of 0.001. For females this produced a statistic value of 0.142, 59 degrees of freedom and a p-value of 0.005. A P-value larger than 0.05 would mean the data is normally distributed and a p-value of less than or equal to 0.05 means the data is not normally distributed. Both P-values for males and females are less than 0.05, meaning that the distribution of years for males and females before getting injured are not normally distributed.

Looking at a histogram of the distribution of years would show a bell-curve positively skewed to the right. This distribution is depicted in figure 4.17 above using a box plot. Due to the mean scores that were being compared in this cross tabulation and upon analysis, it was recommended by the statistician that a box plot be utilised as it best represents the data. This is the reason for the single use of a box plot in this study. The horizontal black line through the blue squares represent the median values for each group. The lowest and highest horizontal lines represent the range (minimum to maximum), with 50% of the population represented between the minimum and the median, and the other 50% between the median and maximum. The blue squares represent the interquartile range which is the range between 25 and 75% of the population.

For males, the median was 2 years, the minimum was 3 weeks (0.06 years), the maximum was 6.83 years, and the range was 6.77 years. The 3 dots at the top of the graph represent the three outliers in the data. For females, the median was 1.75 years, the minimum was 2 months (0.17 years), the maximum was 5 years, and the range was 4.83 years.

Although the data was not normally distributed, parametric testing was still done because both groups of males and females were larger than 50 and of similar size.

Table 4.10: Table depicting group statistics of T-Test for males and females

Gender	**N**	**Mean**	**Standard Deviation**
Male	73	2.32	0.15719
Female	59	1.26	0.16413

As depicted in table 4.10 above, for the group of 73 males the mean value was 2.32 years and for the group of 59 females the mean value was 1.26 years. A T-Test produced a standard deviation of 0.15719 for males and 0.16413 for females. Within an Independent Samples Test, Levine's Test for Equality of Variances produced a test statistic of 0.043 and a p-value of 0.836. Because the p-value is more than 0.05 this means that variances between the groups of males and females are equal. T-Test for Equality of Means produced a test statistic of 1.726, 130 degrees of Freedom and a p-value of 0.087. Because this p-value is larger than 0.05, there is no statistically significant difference between males and females in relation to the average time of CrossFit® participation before an injury was sustained.

4.5.6 Number of CrossFit® related injuries and mobility sessions

Table 4.11: Table depicting the number of injuries in relation to number of mobility sessions

		How many CrossFit® injuries have you sustained since starting CrossFit® training?					
How many days per week do you participate in mobility training on average?			0	1	2	3 or more	Total
	0-1	Frequency	29	20	19	13	81
		Percent	35,8%	24,7%	23,5%	16,0%	100,0%
	2	Frequency	32	21	19	11	83
		Percent	38,6%	25,3%	22,9%	13,3%	100,0%
	3 or more	Frequency	33	19	15	15	82
		Percent	40,2%	23,2%	18,3%	18,3%	100,0%
Total		Frequency	94	60	53	39	246
		Percent	38,2%	24,4%	21,5%	15,9%	100,0%
Pearson Chi-square		Value		df		p-value	
		1.569		6		0.955	

As depicted in table 4.11 above, for each category of number of injuries sustained (0, 1, 2, 3 or more), the number of mobility sessions did not appear to have any significant effect in relation to the number of injuries sustained. This was confirmed using a Pearson Chi-Square test which produced a value of 1.569, 6 degrees of freedom and a p-Value of 0.955. Due to the p-value being more than 0.05, the number of injuries in relation to the number of mobility sessions is of low significance.

4.5.7 Number of mobility sessions and diagnoses

The following results pertain to table A1 which can be found in the appendices due to its large size. As depicted in this table, the three most diagnosed conditions were Strain/sprain (25.3%), general inflammation and pain (24.2%) and overuse injury (20%). When looking at the number of mobility session in relation to diagnoses as seen in table A1, there is no indication of any significant effect. The percentages for each category of number of mobility sessions per week compared to the three most diagnosed conditions were very similar. Due to the multiple response nature of the data, no significant difference could be established between the number of mobility sessions per week in relation to different injury diagnoses.

4.5.8 Age and number of injuries

As seen in table 4.12 below, when looking at age as a variable in relation to number of injuries, no identifiable pattern could be found and there were minimal differences between age categories and the number of injuries sustained in each category. Especially when compared to the total number of injuries in each age category.

The Pearson Chi-square test produced a value of 8.085, 9 degrees of freedom and a p-value of 0.526. Due to the p-value being more than 0.05 it was established that age played no significant role in the number of injuries sustained by participants in this study.

Table 4.12: Table depicting the number of injuries in relation to age groupings

		Number of injuries				
Age		**0**	**1**	**2**	**3 or more**	**Total**
28 years or younger	Frequency	20	20	13	8	61
	Percent	32,8%	32,8%	21,3%	13,1%	100,0%
29-35 years	Frequency	27	9	17	10	63

	Percent	42,9%	14,3%	27,0%	15,9%	100,0%
36-45 years	Frequency	15	14	9	8	46
	Percent	32,6%	30,4%	19,6%	17,4%	100,0%
46 years or older	Frequency	8	3	5	3	19
	Percent	42,1%	15,8%	26,3%	15,8%	100,0%
Total	Frequency	70	46	44	29	189
	Percent	37,0%	24,3%	23,3%	15,3%	100,0%
Pearson Chi-Square	**Value**		**df**		**p-value**	
	8.085		9		0.526	

4.5.9 Age and injury regions

For the three most prevalent injuries, namely shoulder, lower back and knee, no significant difference was found in relation to different age categories. Thus, for each injury region, the percentage of injuries per age category were similar. Therefore, no significant effect on injury regions could be determined by age.

4.5.10 Number of CrossFit® training sessions per week and injury numbers

As seen in table 4.13 below, 52.1% or 37 participants who took part in CrossFit® Training 1 to 3 times per week reported not sustaining any CrossFit® related injuries and within this category the injured majority reported 1 injury. 32.8% or 21 participants who took part in CrossFit® training 4 times a week reported not sustaining any CrossFit® related injuries and within this category the injured majority reported 1 injury.

Table 4.13: Table depicting the number of injuries in relation to the number of CrossFit® sessions per week

Number of CrossFit® sessions per week		**Number of injuries**				
		0	**1**	**2**	**3 or more**	**Total**
1-3	Frequency	37	19	5	10	71
	Percent	52,1%	26,8%	7,0%	14,1%	100,0%
4	Frequency	21	17	13	13	64
	Percent	32,8%	26,6%	20,3%	20,3%	100,0%
5	Frequency	24	14	20	5	63
	Percent	38,1%	22,2%	31,7%	7,9%	100,0%
More than 5	Frequency	16	10	15	11	52
	Percent	30,8%	19,2%	28,8%	21,2%	100,0%
Total	Frequency	98	60	53	39	250
	Percent	39,2%	24,0%	21,2%	15,6%	100,0%
				Value	**Df**	**P value**
Pearson Chi-Square				21.516	9	0,011
Cramer's V				0,169		0,011

38.1% or 24 participants who took part in CrossFit® training 5 times a week reported not sustaining any CrossFit® related injuries and within this category the injured majority reported 2 injuries. 38.8% or 16 participants who took part in CrossFit® training more than 5 times a week reported not sustaining any CrossFit® related injuries and within this category the injured majority reported 2 injuries.

A Pearson Chi-Square test was performed and produced a value of 21.516, 9 degrees of freedom and a p-value of 0.011. Due to the low p-value, the effect size was also calculated to determine if the number of CrossFit® training sessions per week made a difference to the number of injuries sustained. This produced a Cramer's V value of 0.169, which translate to a small to medium effect size thus indicating a significant difference between the number of CrossFit® sessions per week in relation to the number of injuries sustained.

4.5.11 Number of CrossFit® training sessions per week and injury diagnoses

The following results pertain to table A2 which can be found in the appendices due to its large size. As depicted in this table, the three most prevalent injury diagnoses were general inflammation and pain, overuse injuries and strains/sprains.

Majority of overuse injury and strain/sprain diagnoses were recorded by participants that took part in CrossFit® training more than 5 times a week. Majority of general inflammation and pain diagnoses were recorded by participants that took part in CrossFit® training 5 times a week. The least amount recorded for all three of the most prevalent injury diagnoses were in participants that took part in 1 to 3 CrossFit® training sessions per week.

Due to the multiple response nature of the data, no significant difference could be established between number of CrossFit® training sessions per week in relation to different injury diagnoses. However, more training sessions do seem to be associated with more total injury diagnoses within this study.

4.5.12 Strength training and number of injuries

As seen in the table 4.14 below, there does seem to be a slight pattern of higher injury numbers with increased number of strength training sessions per week. However, the difference in percentages between groups are minimal and overall proportions are similar.

Table 4.14: Table depicting the number of injuries in relation to the number of strength training sessions per week

Number of strength training sessions		**Number of injuries**				
		0	**1**	**2**	**3 or more**	**Total**
1-2	Frequency	19	11	7	7	44
	Percent	43,2%	25,0%	15,9%	15,9%	100,0%
3	Frequency	39	27	17	12	95
	Percent	41,1%	28,4%	17,9%	12,6%	100,0%
4 or more	Frequency	39	21	29	19	108
	Percent	36,1%	19,4%	26,9%	17,6%	100,0%
Total	Frequency	97	59	53	38	247
	Percent	39,3%	23,9%	21,5%	15,4%	100,0%
Pearson Chi-Square	**Value**		**df**		**p-value**	
	5.731		6		0.454	

A Pearson Chi-Square test was performed to determine the significance of the findings and produced a value of 5.731, 6 degrees of freedom and a p-value of 0.454. Due to the p-value being more than 0.05, it was determined that the number of strength training sessions did not have a statistically significant impact on the number of injuries sustained by participants.

4.5.13 Strength training and injury diagnoses

The number of strength training sessions per week were compared to the three most prevalent injury diagnoses. For general inflammation and pain as well as sprains/strains the values were similar and did not follow any pattern. Increased number of strength training sessions appeared to have higher rates of overuse injuries however, these numbers did not differ significantly. Due to the multiple response nature of the data, no significance difference could be established between the number of strength training sessions per week and injury diagnoses.

CHAPTER 5 - DISCUSSION

5.1 Introduction

The results obtained from the research that was presented in chapter four are discussed and explained throughout this chapter. The aim of this research was to investigate the incidence of injuries and the associated potential risk factors relating to Johannesburg-based athletes participating in CrossFit®.

5.2 Demographic Information of the Sample Population

5.2.1 Age distribution

Participants had to be of age 18 years or older, this was one of two inclusion criteria that had to be met in order to participate in the study. The youngest participant in this study was 18 years of age and the oldest was 71 years of age. The average age was 33.5 with a standard deviation of 8.7. The most common age was 32. This age distribution is similar to the study by Mehrab et al. (2017) who reported an average age of 32 and a standard deviation of 8.3 years.

Cross correlations between different age categories and number of injuries revealed no identifiable pattern with minimal difference between age categories and the number of injuries sustained in each category. This was further supported by a p-value calculated to be 0.526 which is not statistically significant ($p > 0.05$).

For the three most prevalent injuries, namely shoulder, lower back and knee, no significant difference was found in relation to different age categories. Thus, for each injury region, the percentage of injuries per age category were similar. Therefore, no significant effect on injury regions could be determined by age.

A review of multiple studies by Tabana et al. (2018) also found no significant risk of injury among adults in different age groups. It can therefore be reasoned that with proper coaching and supervision, CrossFit® can be practiced safely by older athletes across any age group

(Weisenthal et al., 2014). Mehrab et al. (2017) also found age to be of little to no significance in relation to any variables regarding CrossFit® related injuries.

5.2.2 Gender distribution

The gender distribution of this study was 125 males and 125 females, each making up 50% of the total 250 participants. CrossFit® is known for its inclusiveness of gender as is reflected in this study as well as multiple similar studies such as Feito et al. (2018) and Mehrab et al. (2017)

Cross correlation between males and females in relation to their participation time in CrossFit® prior to injury revealed a mean of 2.32 years for males and 1.26 years for females. Tests for normality produced high p-values for both males and females meaning that the data was not normally distributed. Testing for equality of means produced a p-value of 0.087 meaning that there was no statistically significant difference between males and females in relation to the average time of CrossFit® participation before an injury was sustained ($p > 0.05$). Mehrab et al. (2017) also failed to find any significant difference between males and females in relation to the average time of CrossFit® participation before an injury was sustained.

5.3 Training Information of the Sample Population

5.3.1 Time elapsed participating in CrossFit®

The largest majority of participants (41.6% or 104 athletes) were those who had been taking part in CrossFit® training for 2 to 5 years. The second largest majority was 24.8& or 62 participants who had been taking part in CrossFit® training for more than 5 years. This is in line with findings by Mehrab et al. (2017) who noted the majority of participants to have been doing CrossFit® for two or more years and Feito et al. (2018) who reported a majority of more than three years of CrossFit® participation.

Feito et al. (2018) and Szeles et al. (2020) reported that athletes with less than one year of CrossFit® experience were more likely to report an injury compared to those athletes with more training experience. However, injuries are caused by a multitude of factor and cannot simply be attributed to experience. The possibility exists that although certain athletes new to the sport lack experience in the sport, they may be more athletic due to previous training experience and therefore are able to push themselves more when starting CrossFit® and put themselves at greater risk for injury (Feito et al., 2018).

5.3.2 Beginners programs

Majority of participants (81%) stated that their gymnasium offered a beginner's program, with 59 percent of the majority stating that it was mandatory for all new members when starting CrossFit®. This is similar to Mehrab et al. (2017) who reported 88.4% of participants in their study attended gymnasiums that offered a beginner's program.

When cross tabulated with number of injuries, there was minimal, if any difference in the percentage of injuries between gymnasiums that provided and mandated a beginners program, those that provided an optional beginners program, and those that did not provide any beginners program. The p-value was calculated to be 0.637 which is not statistically significant ($p > 0.05$). Due to the small sample size of participants, it cannot be generalised to a wider population of CrossFit® athletes. This result was surprising however as both studies by Mehrab et al. (2017) and Aune and Powers (2017) indicated that athletes participating in CrossFit® for less than six months were at significantly higher risk of injury. As a result it is still suggested that all new athletes take part in a beginners program and scale their training, for at least the first six months, to train within their abilities to prevent potential injuries (Feito et al., 2018; Szeles et al., 2020).

5.3.3 Number of days participating in CrossFit® per week

Majority of participants indicated training between three and six days per week. Especially four and five days a week with 64 (25.6%) and 63 (25.2%) participants, respectively. This could be due to the progressive nature of CrossFit® as a training methodology. Athletes may start out only doing one or two sessions a week but as they progress in strength and skill, they are able to handle more volume and recover quicker. The community and accountability aspect that CrossFit® is known for could also play a role in increased participation (Whiteman-Sandland, Hawkins and Clayton, 2018; Toland, 2017).

Cross correlation between number of CrossFit® training sessions per week and number of injuries sustained produced a p-value of 0.011. Due to the low p-value, the effect size was also calculated. This produced a Cramer's V value of 0.169, which translate to a small to medium effect size thus indicating a significant difference between the number of CrossFit® sessions per week in relation to the number of injuries sustained. Statistically this meant that an increase in the number of CrossFit® training sessions per week was associated with an increase in relation to the number of injuries sustained. Unfortunately, when looking at the data, no pattern could be decerned without advanced statistical analysis as the values were quite similar. This was contrary to results by Feito et al. (2018) who reported that athletes who participated in less than 3 CrossFit® training sessions a week were more likely to report an injury compared to those that participated in 4 to 5 training sessions per week. It stands to reason that a case could be made for either argument. However, Mehrab et al. (2017) did not report any significance between the number of CrossFit® training sessions per week in relation to the number of CrossFit® related injuries sustained.

5.3.4 Multiple training sessions

Less than 15% of participants in this study indicated training more than once per day. This was likely due to participants' own time constraints and lack of incentive to do extra training since CrossFit® classes already cover multiple aspects and modalities of fitness, all within an hour-long class. In Greg Glassman's own word: "It turns out that the intensity of training that optimizes physical conditioning is not sustainable past 45 minutes to an hour. Past one hour, more is not better" (Glassman, 2010). Thus, CrossFit® could be considered as a time efficient and effective training method (Meyer, Morrison and Zuniga, 2017). Mehrab et al. (2017) did not report any significant result regarding athletes who trained multiple times per day.

5.3.5 Number of rest days per week

Rest days were defined as any day not participating in CrossFit® training; however, Sundays were considered as rest days regardless. 96 participants (38.4%) took two rest days a week and 68 participants (27.2%) rested one day per week. These values were not inverse to the results of the number of training days per week. This was likely due to errors on behalf of participants while completing the survey due to not reading the question correctly or incorrectly filling in information. Mehrab et al. (2017) did not report any significant result regarding the number of rest days taken per week.

5.3.6 Number of strength training sessions per week

Majority of participants indicated taking part in three (95 participants or 38.5%) and 4 or more (108 participants or 43.7%) strength training sessions per week. This could be attributed to strength training being an integral part of CrossFit® classes (Glassman, 2010).

Cross correlation between the number of strength training sessions per week and number of injuries sustained produced a p-value of 0.454 which was not statistically significant ($p > 0.05$). Even though there does seem to be a slight pattern of higher injury numbers with increased number of strength training sessions per week, the difference in percentages between groups were minimal and overall proportions were similar. Thus, it was determined that the number of strength training sessions did not have a statistically significant impact on the number of injuries sustained by participants. It stands to reason though that even if the risk of injury associated with strength training was low, the more time an athlete spends doing strength training, the higher their chance of getting injured. These risks could be mitigated by appropriate scaling of load and movement as well as erring on the side of caution and focussing on perfecting form instead of chasing strength numbers (Glassman, 2010). Mehrab et al. (2017) did not report any significant result regarding the number strength training sessions per week.

5.3.7 Technique/skill training sessions per week

Majority of participants indicated taking part in three (83 participants or 33.5%) and 4 or more (92 participants or 37.1%) technique/skill training sessions per week. Mehrab et al. (2017) did not report any significant result regarding the number technique/skill training sessions per week. Regardless of the result or how gymnasiums go about incorporating technique practice into their class, technique was considered of paramount importance within CrossFit®. Within the level 1 training guide it is described as “an intimate part of safety, efficacy and efficiency and maximises the work accomplished for the energy spent” (Glassman, 2010).

5.3.8 Warm up structure

The most popular warm up routine involved movement specific exercises (213 responses), some form or another of full body exercise (212 responses) and gradually working up to weights that would be used in the workout. All except 2 participants stated using some form of warm up before training. Every CrossFit® class has a warmup component to it and is included in the class structure discussed in the level 1 training guide (Glassman, 2010). The two participants who did not use any warmup structure were most likely not involved in CrossFit® classes and possibly training on their own outside of class times. Mehrab et al. (2017) did not report any significant result regarding warmup structure. Due to the multiple response nature of the data in the current study, no significant result was found in relation to warm up structure.

5.3.9 Number of mobility training sessions per week

On average, mobility training was utilised twice a week by 83 participants (33.7%) and at least once a week by 56 participants (22.8%). These number are very low in comparison to strength training. This could be due to multiple factors including low prioritisation of mobility by participants/coaches or a lack of definition of the term mobility within the survey.

Cross correlation between the number of CrossFit® related injuries in relation to the number of mobility sessions produced a p-value of 0.955 which is not statistically significant. Thus, the number of CrossFit® related injuries in relation to the number of mobility sessions was of low significance. Mehrab et al. (2017) did not report any significant result regarding the number of mobility training sessions per week. Currently there were no CrossFit® related studies focusing on mobility. This could be an avenue for future research.

5.3.10 Participation in sports in addition to CrossFit®

Almost half of the participants in this study (107 or 42.8%) stated that they were involved in sporting activities outside of CrossFit®. Running, cycling and swimming were shown to be the most popular non-CrossFit® activities. Although this question was included in the survey, due to the multiple response nature of the data, no relationship could be established between CrossFit® related injuries and additional sport participation outside of CrossFit®. Study by Mehrab et al. (2017) (upon which the current study's questionnaire was based) also included this question within their survey but was omitted in the final results and discussion due to a lack of significance during statistical analysis within their own as well as in other similar studies (Aune and Powers, 2017). CrossFit® methodology encourages athletes to regularly practice and engage in new sports or physical activities, using the fitness gained in the gymnasium and applying it to various physical challenges outside (Glassman, 2010).

5.4 Injury data of Sample Population

5.4.1 Number of injuries since starting CrossFit®

The injury incidence of this study was shown to be 60.2%, with 152 participants reporting at least one CrossFit® related injury since starting CrossFit® training. This was slightly higher than the study by Mehrab et al. (2017) who reported an injury incidence of 56.1%. More than a third or 98 participants (39.8%) in this study reported no CrossFit® related injuries since starting CrossFit® training. Of those who sustained injuries, the majority (60 participants or 24%) reported being injured only once.

A review of the literature examining CrossFit® related injuries found injury incidence rates ranging from 19.4% to 73.5% (Tibana and Sousa, 2018). The vast difference in results might be attributed to the definition of injury being used which differs greatly from one study to the next. Hak et al. (2013) defined an injury as "any injury sustained during training that prevented the participant from training, working, or competing in any way and for any period of time". This broad definition may explain the high injury incidence rate of 73.5%.

The current study made use of a stricter definition originally used by Weisenthal et al. (2014) and Sprey et al. (2016). A strict definition of injury was used in this study, to avoid confusion and incorrect reporting of injuries. Due to the high intensity and constantly varied nature of CrossFit®, athletes are often sore or have some discomfort following their training sessions and this might be considered by some to constitute injury. Despite using the stricter definition of injury, the injury incidence rate of this study is higher than of Weisenthal et al. (2014) and Sprey et al. (2016). This could be due to differences in CrossFit® practice, programming and coaching knowledge within different countries or simply due to participants not reading certain questions correctly.

Cross correlation between males and females in relation to number of injuries showed a lower overall injury incidence for females compared to males. Males reported higher overall injury numbers (159) compared to females (110). This agreed with findings by Moran et al. (2017) and Weisenthal et al. (2014) who also reported higher injury incidence in males compared to females. The p-value was calculated to be 0.15 which is not statistically significant ($p > 0.05$). However, the Cramer's V value of 0.205 revealed a medium effect size, thus indicating a significant difference between males and females in relation to number of injuries sustained.

Males are more likely to get injured compared to females due to a multitude of factors. One of which was the likelihood of past training experience or simply just more years of training experience in other modes of fitness compared to females. This means that when starting CrossFit® training most males would be using heavier weights from the start. Males also tend to let their ego's get the better of them, leading to injury. Females tend to be more cautious, ask more questions and request more assistance from coaches, thus the chance of injury decreases (Feito et al., 2018; Weisenthal et al., 2014).

Ultimately CrossFit® is a sport and training methodology consisting of multiple components from different sports, some of which require a higher level of skill, technique, strength and flexibility. The selection and combination of these components as well as the recommended weight and scaling options for each component were determined by coaches (Szeles et al., 2020). However, despite best efforts, coaches could only do so much, and the final decision always rests with the athlete.

5.4.2 Regional injuries since starting CrossFit®

A total of 269 injuries were reported. The three most injured regions were the shoulders (25.7%), low back (24.9%) and knees (14.1%) and accounted for just under 65 percent of all listed injuries. This was in accordance with available literature involving CrossFit® related injuries and multiple studies done across the world as discussed in chapter 2. The same patterns of injury could be found in the sports that make up CrossFit®. Powerlifters and Olympic weightlifters report higher instances of shoulder, lower back and knee injuries (Ruske and Norlin, 2002). Gymnasts have higher proportions of shoulder injuries and runners have higher proportions of knee and lower limb injuries (Caine and Nassar, 2005; Jacobsson, Timpka, Kowalski, Nilsson, Ekberg and Renström, 2012). Comparison between males and females in relation to injury regions showed that majority of injuries in females occurred in the lower back (28.2%), shoulder (22.7%) and knee (13.6%) region. For males, majority of injuries occurred in the shoulder (27.7%), lower back (22.6%) and knee (14.5%) region. The higher rate of shoulder injuries in males could be due to lifting more weight overhead compared to females as well as having to support more absolute bodyweight when performing gymnastics-based movements such as handstand push ups and handstand walks.

5.4.3 Elapsed time participating in CrossFit® when injuries occurred

The average time of participation in CrossFit® training prior to sustaining a CrossFit® related injury was 2.1 years. The shortest participation time prior to sustaining an injury was 3 weeks and the longest was 6.8 years.

Multiple studies have shown that athletes who had more experience in CrossFit® were at a lower risk of sustaining a CrossFit® related injury (Szeles et al., 2020). This directly contradicts the findings of Montalvo et al. (2017) who stated that more experience lead to higher odds of sustaining an injury. It stands to reason that more experienced athletes would have more refined techniques and better load management than less experienced athletes and thus have a lower risk of injury. However, the argument could also be made that the higher load, frequency and intensity of experienced athletes put them at greater risk of injury. This could be an avenue for future research.

5.4.4 Abstaining from training

Of the 247 responses, 127 (51.4%) of the reported injuries led to participants abstaining from training due to injury. The remaining 120 (48.6%) reported injuries did not require participants taking time off from training. 54.4% of males and 47 percent of females reported abstaining from training due to injury. This could be due to males sustaining more serious injuries compared to females due to higher loads used in training by males. Mehrab et al. (2017) did not find any significant results regarding athletes who abstained from training due to injury.

5.4.5 Diagnoses of injuries

Majority of injuries were soft tissue related. The 3 most diagnosed conditions were general inflammation and pain (30.4%), sprains/strains (25.3%) and overuse injuries (20%).

When looking at the number of mobility sessions in relation to diagnoses, there was no indication of any significant effect. The percentages for each category of number of mobility sessions per week compared to the three most diagnosed conditions were very similar. Due to the multiple response nature of the data, no significant difference could be established between the number of mobility sessions per week in relation to different injury diagnoses.

Cross correlation between the number of strength training sessions per week in relation to the three most prevalent injury diagnoses, it was found that general inflammation and pain as well as sprains/strains had similar values but did not follow any pattern. Increased number of strength training sessions appeared to have higher rates of overuse injuries however, these numbers did not differ significantly. Due to the multiple response nature of the data, no significance difference could be established between the number of strength training sessions per week and injury diagnoses.

5.4.6 Discomfort prior to injuries

For those participants who reported injuries, 70.2% did not experience any discomfort in the region prior to the injury. 17.2% reported experiencing pain and/or stiffness in the region during the week leading up to the injury. 12.7% reported experiencing pain and/or stiffness in the region for more than a week before the injury. These results agree with finding by Weisenthal et al. (2014). Majority of reported CrossFit® related injuries seem to be acute in nature with participants reporting general inflammation and pain and strains/sprains as opposed to more severe injuries such as fractures and dislocations. This suggested that CrossFit® related injuries were minor and with the correct scaling and supervision, a return to participation was very likely (Weisenthal et al., 2014).

5.4.7 Injury activity and mechanism

Majority of injuries occurred during the WOD (44%) and strength training (30.5%). These results are similar to Mehrab et al. (2017) who stated that injuries were most frequent during WODs (39.7%) and strength training (21.4%).

Three injury mechanisms were attributed to majority of reported injuries. Improper form accounted for 124 (38.4%) injuries; fatigue accounted for 84 (26%) injuries and weights that were too heavy accounted for 59 (18.3%) injuries. Relapse of prior injuries only accounted for 11.1% of listed injuries which was especially surprising as multiple studies stated prior injury as one of the greatest risk factors CrossFit® related injuries (Aune and Powers, 2017).

Weisenthal et al. (2014) found that Olympic lifting and powerlifting movements accounted for almost 40% of all injuries and gymnastics accounted for 20% of all injuries. Kolt and Kirby (1999) reported a higher rate of shoulder injuries in sub-elite gymnasts compared to elite gymnasts. They found that the higher injury rates in sub-elite gymnasts were associated with a difference in the level of gymnastics skill, or lack thereof.

The mechanisms of CrossFit® related injuries and the activities during which they take place were usually a combination of multiple factors irrespective of the activity. One could look at it as a triangle of fatigue, technique/form and inappropriate load. If one of the three breaks down, so would the other two due to the interrelation between these factors. Weights that were too heavy, whether the athlete was fatigued or not, would cause a breakdown in technique if an athlete does not recognise his/her limitation or state of readiness in time. However, if the weight was light enough, whether fatigued or not, the athlete might be careless, or not concentrating as hard, and a breakdown in technique might still lead to improper form and injury. Keeping this in mind it should be very easy to understand why majority of injuries occur during WODs (Aune and Powers, 2017).

During a WOD, the objective was to complete all the movements in the fastest time possible, with good form, whilst managing fatigue. This was completely possible with appropriate loading and scaling of movements, and correct pacing for intensity relative to the individual. Unfortunately, most athletes, especially beginners do not have the experience and body awareness to gauge the pace of a workout and therefore fatigue early, leading to breakdown in the rest of the triangle. Scaling of load and movement should be advised by the coach, but ultimately it was the responsibility of the athlete to determine their own level of intensity and to err on the side of caution if they were uncertain (Aune and Power, 2017; Szeles et al., 2020).

5.4.8 Health professional consulted

Physiotherapists and chiropractors were by far the most consulted health professionals for CrossFit® related injuries. Physiotherapists were consulted for 39.7% of reported injuries and chiropractors were consulted for 34.3% of reported injuries. This was similar to findings by Aune and Powers (2017) who reported that 34% of injuries were seen to by physical therapists. Since majority of CrossFit® related injuries were soft tissue injuries, it was understandable that physical therapy would be an injured athletes' first choice of treatment. None of the currently available CrossFit® injury related literature specifically asks about chiropractors treating injured athletes. Therefore, this was the first study to specifically inquire about the role of chiropractic in treating CrossFit® related injuries. This was surprising considering that lower back injuries were so prevalent among CrossFit® athletes.

A study by Moehlecke and Forgiarini (2017) compared two groups of CrossFit® athletes complaining of lower back pain. The first group received a chiropractic manipulation to the lower back and the second, a control group, received no treatment. The results were a decrease in pain and an increase in lumbar range of motion following a chiropractic manipulation in the first group compared to the control group who reported no decrease in pain. One would surmise that since chiropractors were expertly trained in biomechanical and musculoskeletal spinal conditions (Bergmann, Peterson and Lawrence, 2011) and manipulation, having been proven effective as well as a cost-effective treatment, that they would be the first practitioners consulted after sustaining an injury (Khodakarami, 2020).

More research regarding CrossFit® related injuries and chiropractic manipulation are needed and could provide an avenue for future research.

CHAPTER 6 - CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The aim of this study was to investigate the incidence of injuries and potential risk factors related to CrossFit® participation in Johannesburg, South Africa.

The study reported a CrossFit® related injury incidence of 60.2% which was in agreement with other studies of a similar design. This number may seem high but all the available research points to the injury incidence in CrossFit® being comparable to, and at times less than, other popular recreational or competitive sports such as running and cycling. The most commonly injured body regions, for both males and females, were the shoulder, lower back and knee. The most injured body region for males was the shoulder and the most injured body region for females was the lower back. Gender was shown to be the most significant risk factor with males reporting more injuries than females. However, the average time participating in CrossFit® prior to sustaining an injury was 1.2 years for females and 2.3 years for males. Injury patterns in CrossFit® were similar to the sports that constitute it, namely powerlifting, Olympic weightlifting, gymnastics and running. Unfortunately, injuries sustained prior to starting CrossFit® were not taken into account by this study. Other factors such as mobility, strength and technique training, beginners' programs, warm up structure, additional sporting participation etc, did not result in any significant findings in relation to injury incidence which was a similar result to other studies. The current research was the first study of its kind to be conducted in South Africa and could be used as a base for future studies to build upon.

In conclusion, multiple studies including the current research have shown that CrossFit® is not the dangerous fitness fad as portrayed by the media and uninformed health practitioners. With correct coaching and supervision CrossFit® could be practiced safely by participants of any age, gender, ability or skill level and has been proven to be an effective form of exercise.

6.2 Recommendations

The following recommendations were made pertaining to future research:

1. A larger sample group is recommended in order to ensure a better representation of the larger CrossFit® population. This could be achieved by conducting in-person surveys with athletes at their gymnasiums. Emails are easily ignored or looked over and thus the in-person option allows for more detailed and correctly completed surveys.
2. Increasing the survey response rate could be achieved by offering incentives to athletes that are willing to take part in the survey in a manner agreed upon with each gymnasium.
3. The online survey could be distributed to gymnasiums across the country to ensure a better representative data set.
4. A similar study could be conducted examining the injury characteristics and analysing the profile of beginner versus experienced CrossFit® athletes to determine potential causes and mechanisms of injury.
5. The same study could also be conducted on recreational versus competitive CrossFit® athletes.

Further research could also be conducted on the treatment of CrossFit® related injuries by health practitioners with an emphasis on chiropractic.

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APPENDIX A – Permission letter

Letter requesting permission from box owners/coaches to survey members

Dear Box Owner/Coaches

My name is **Marius Steenkamp**, I am currently completing my master's degree in Chiropractic. I am a final year student in the process of completing my dissertation, which is a requirement of my degree. In order to do this, I will need to conduct a research study, which will involve the participation of Box members.

My research topic is: **"Injury Incidence and Risk Factors in CrossFit® Athletes In Johannesburg"**

I am writing this email to request permission from you to be able to survey members of your box that would be willing to partake in my research.

THE PURPOSE OF THIS STUDY is to determine the injury rates and risk factors of CrossFitters in Johannesburg and to compare these values to similar studies done abroad. Since there is no injury data for CrossFit® in South Africa, anyone can make exaggerated and unsupported claims about CrossFit®. This study aims to gather data in a South African context that is useful to coaches and health practitioners.

Please see attached information letter (Appendix D) and questionnaire (Appendix C) that participants will be asked to complete should they choose to partake in my research study.

Please do not hesitate to contact me if are interested in partaking in my research

Kind Regards,

Marius Steenkamp

201007209

Chiropractic Masters student

APPENDIX B – Information letter

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF CHIROPRACTIC

RESEARCH STUDY INFORMATION LETTER

REC 11.0

Are you an avid CrossFitter?

You are needed for Research!

All you need to do is complete the online survey by clicking on the link in the email.

15 minutes or less and you can make a difference.

Good Day

My name is Marius Steenkamp. **I WOULD LIKE TO INVITE YOU TO PARTICIPATE** in a research study on "Injury Incidence and Risk Factors in CrossFit® Athletes In Johannesburg"

Before you decide on whether to participate, I would like to explain to you why the research is being done and what it will involve for you. **All the information is stated below and the questionnaire is self explanatory.** This should take about 10 to 15 minutes. The study is part of a research project being completed as a requirement for a Masters Degree in Chiropractic through the University of Johannesburg.

THE PURPOSE OF THIS STUDY is to determine the injury rates and risk factors of CrossFitters in Johannesburg and to compare these values to similar studies done abroad. Since there is no injury data for CrossFit® in South Africa, anyone can make exaggerated and unsupported claims about CrossFit®. This study aims to gather data in a South African context that is useful to coaches and health practitioners.

Below, I have compiled a set of questions and answers that I believe will assist you in understanding the relevant details of participation in this research study. Please read through these. If you have any further questions, I will be happy to answer them for you.

1. **DO I HAVE TO TAKE PART?** No, you don't have to. It is up to you to decide to participate in the study. If you agree to take part, I will then ask you to sign a consent form.

2. **WHAT EXACTLY WILL I BE EXPECTED TO DO IF I AGREE TO PARTICIPATE?** All you need to do is fill in the survey on your smart phone or computer.

3. **APPROXIMATELY HOW LONG WILL MY PARTICIPATION TAKE?** Your participation will take approximately 10 to 15 minutes. The questionnaire (Appendix C) is self-explanatory and straight forward.

4. **WHAT WILL HAPPEN IF I WANT TO WITHDRAW FROM THE STUDY?** If you decide to participate, you are free to withdraw your consent before submission without giving a reason and without any consequences. If you wish to withdraw your consent, please do so before submitting.

5. **IF I CHOOSE TO PARTICIPATE, WILL THERE BE ANY EXPENSES FOR ME, OR PAYMENT DUE TO ME?** If you choose to participate, you will not be paid to participate in this study, and you will not bear any expenses.

6. **IF I CHOOSE TO PARTICIPATE, WHAT ARE THE RISKS INVOLVED?** If you decide to participate, there are no anticipated risks involved

7. **IF I CHOOSE TO PARTICIPATE, WHAT ARE THE BENEFITS INVOLVED?** If you choose to participate, you will be contributing to the presently scarce body of information relating to CrossFit® injury rates and risk factors in a South African context. This research could also potentially contribute to the broader society as it will inform CrossFit® athletes and their coaches about potential risks for injury and how they can be prevented.

8. **WILL MY PARTICIPATION IN THIS STUDY BE KEPT CONFIDENTIAL?** All reasonable efforts will be made to keep your personal information confidential and respect your right to privacy. This includes replacing your identifying personal information with a number that only I and my research supervisor will know. You will not be identified in any research reports that are published. Under some circumstances, such as when required to do so by a court of law, I may have to disclose your personal information. In addition, it may happen that your information will need to be reviewed by another organisation for quality assurance purposes. I will tell you about this if it happens.

9. **WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY?** The results will be written into a research report that will be assessed. In some cases, results may also be published in a scientific journal. In either case, you will not be identifiable in any documents, reports or publications. You will be given access to the results of this if you would like to see them, by contacting me. If you decide to seek effective treatment post-trial, you will be offered the opportunity to do so.

10. **WHAT WILL YOUR RESPONSIBILITIES BE, AS THE RESEARCHER?** My responsibilities as the researcher will include the safekeeping of personal information of research participants, accurate interpretation of data, maintaining confidentiality and adhering to ethical conduct.

11. **WHO IS ORGANISING AND FUNDING THIS RESEARCH STUDY?** The study is being organised by me, under the guidance of my research supervisor at the Department of Chiropractic at the University of Johannesburg. Costs will be covered by supervisor linked bursary for masters students

12. **WHO HAS REVIEWED AND APPROVED THIS STUDY?** Before this study was allowed to start, it was reviewed in order to protect your interests. This review

was done first by the Department of Chiropractic, and then secondly by the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg. In both cases, the study was approved.

13. **ARE THERE ANY CONFLICT OF INTERESTS PERTAINING TO THIS STUDY?** There is no conflict of interests held by anyone involved in this study**.**

14. **WHAT IF THERE IS A PROBLEM?** If you have any concerns or complaints about this research study, its procedures or risks and benefits, you should ask me. Feel free to contact me at any time if you feel you have any concerns about being a part of this study. My contact details are:

Marius Steenkamp

082 476 9163

Marius.mls@gmail.com

You may also contact my research supervisor:

Dr Caroline Hay

Carolineh@uj.ac.za

If you feel that any questions or complaints regarding your participation in this study have not been dealt with adequately, you may contact the Chairperson of the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg:

Prof. Christopher Stein

Tel: 011 559-6564

Email: cstein@uj.ac.za

FURTHER INFORMATION AND CONTACT DETAILS: Should you wish to have more specific information about this research project information, have any questions, concerns or complaints about this research study, its procedures, risks and benefits, you should communicate with me using any of the contact details given above.

Researcher:

Marius Steenkamp

APPENDIX C – Consent Form (DIGITAL)

DEPARTMENT OF CHIROPRACTIC

RESEARCH CONSENT FORM

REC 11.0

Injury Incidence and Risk Factors in CrossFit® Athletes In Johannesburg

Please check each box below:

☐ I confirm that I have read and understand the information letter for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

☐ I understand that my participation is voluntary and that I am free to withdraw from this study before submitting without giving any reason and without any consequences to me.

☐ I agree to participate in the above research and acknowledge that by clicking "continue" I will be starting the questionnaire and fully consent my participation in the study

☐ Continue

APPENDIX D – Survey

PLEASE ANSWER THE FOLLOWING QUESTIONS BY MARKING THE RELEVENT BLOCK WITH AN ‘X’ OR WRITING DOWN YOUR OWN ANSWERS IN THE SPACE PROVIDED.

Section A – Demographic Data

1.Are you training at a registered CrossFit® Affiliated Gym

Yes	1
No	2

2. Are you of age 18 years or older?

Yes	1
No	2

If the answer is “No” to either or both question 1 and 2, please direct the participant to a page saying: “Unfortunately I’m sad to say you do not meet the criteria for this specific research and are unable to continue. Thank you so much for your time and willingness to contribute to the current body of knowledge.

3. What is your age?

4. Gender

Male	1
Female	2

Section B – Your Training

1. How long have you been doing CrossFit®?

0 - 6 Months	1
6 -12 Months	2
1 - 2 Years	3
2 - 5 Years	4
More than 5 Years	5

2. Does your box provide a beginner's program?

No	1
Yes (It's optional)	2
Yes (It's mandatory)	3
I don't know	4

3. How many days a week do you do CrossFit®?

1	1
2	2
3	3
4	4
5	5
>5	6

4. Do you train multiple times a day?

Yes	1
No	2

5. How many rest days do you take on average per week?

(Rest days from CrossFit® training and not including other forms of activity. Sundays also classify as

rest days, even if the gym isn't open)

None	1
1	2
2	3

3	4
4	5
5	6
More than 5	7

6. How many days a week do you participate in strength training on average?

(These sessions can be part of a ‘Workout Of the Day’ (WOD))

1	1
2	2
3	3
4 or more	4

7. How many days a week do you participate in technique/skill training on average?

(These sessions can be part of a ‘Workout Of the Day’ (WOD))

1	1
2	2
3	3
4 or more	4

8. Which of the following is usually part of your CrossFit® warm-up? (multiple answers allowed)

Full body exercise (running/jump rope/rowing)	1
Static stretching	2
Dynamic stretching	3
Movement specific exercises (e.g. squats before a squat workout)	4
Technique training (practicing skills from weightlifting/gymnastics)	5
Gradual warm-up to workout weight	6
No warming up	7

9. How many days a week do you participate in mobility training on average? (These sessions can be part of a 'Workout Of the Day' (WOD))

0	1
1	2
2	3
3	4
4 or more	5

10. Do you participate in other sports in addition to CrossFit® such as hockey, soccer, tennis etc.?

Yes	1
No	2

If yes, please specify:

____

____

Section C- Injuries

1. How many CrossFit® injuries have you sustained since starting CrossFit® training?

This is explicitly about injuries that you have sustained during CrossFit® training. You have sustained an injury if you met at least one of the following criteria:

- ✓ Total removal from CrossFit® training and other outside routine physical activities for more than one week.
- ✓ Modification of normal training activities in duration, intensity, or mode for more than two weeks.
- ✓ Any physical complaint severe enough to warrant a visit to a health professional.

0	1
1	2

2	3
3 or more	4

Injury Data

2. Please state the thee most significant injuries since starting CrossFit® (based on the definition above) by placing across next to which body part was injured.

	Injury 1	Injury 2	Injury 3
Neck	1	1	1
Lower back	2	2	2
Back	3	3	3
Shoulder	4	4	4
Upper arm	5	5	5
Elbow forearm	6	6	6
Wrist	7	7	7
Hand	8	8	8
Finger(s)	9	9	9
Hip	10	10	10
Groin	11	11	11
Stomach	12	12	12
Upper leg	13	13	13
Knee	14	14	14
Lower leg	15	15	15
Calf	16	16	16
Ankle	17	17	17
Foot	18	18	18
Toe(s)	19	19	19
Other (Specify)	20	20	20

3. For how long were you doing CrossFit when these injuries occurred? (approximately how many years and months since starting)

	Years	Months
Injury 1		
Injury 2		
Injury 3		

4. Did you have to abstain from training due to the injured area(s)?

	Yes	No
Injury 1	1	2
Injury 2	1	2
Injury 3	1	2

5. What was the diagnoses of the injuries?

	Injury 1	Injury 2	Injury 3
No diagnosis was made	1	1	1
Overuse	2	2	2
General inflammation and pain	3	3	3
Stress fracture	4	4	4
Strain/pain	5	5	5
Rupture	6	6	6
Dislocation	7	7	7
Unspecified pain	8	8	8
Other (specify)	9	9	9

6. Prior to the injury, did you feel any discomfort in the injured area?

	Injury 1	Injury 2	Injury 3
No	1	1	1
Yes, pain/stiffness in the week before the injury.	2	2	2
Yes, pain/stiffness longer than a week before the injury.	3	3	3
Other (specify)	4	4	4

7. What were you doing when the injury occurred?

	Injury 1	Injury 2	Injury 3
I don't remember	1	1	1
WOD	2	2	2
Strength Training	3	3	3
Technique training	4	4	4
Running	5	5	5
Cycling	6	6	6
Other (specify)	7	7	7

8. What do you think caused the injury? (Multiple answers possible.)

	Injury 1	Injury 2	Injury 3
Weights too heavy	1	1	1
Improper form	2	2	2
Fatigue	3	3	3
Lack of coaching or bad coaching	4	4	4
Relapse of previous injury	5	5	5
Other (specify)	6	6	6

9. What profession was seen for the injury?

	Injury 1	Injury 2	Injury 3
None	1	1	1
Physiotherapist	2	2	2
Chiropractor	3	3	3
General Practitioner (GP)	4	4	4
Specialist	5	5	5

You have completed the questionnaire.

Thank you so much for your time and participation.

Should you have any further questions or need to get a hold of me, please do not hesitate to do so. My contact details are listed in the information form within the same email as the link.

APPENDIX E – Higher Degrees Committee Letter

FACULTY OF HEALTH SCIENCES

HIGHER DEGREES COMMITTEE

HDC-01-08- 2020

6 April 2020

TO WHOM IT MAY CONCERN:

STUDENT: STEENKAMP, M
STUDENT NUMBER: 201007209

TITLE OF RESEARCH PROJECT: Injury Incidence and Risk Factors in Crossfit® Athletes in Johannesburg

DEPARTMENT OR PROGRAMME: **CHIROPRACTIC**

SUPERVISOR: **Dr C Hay** **CO-SUPERVISOR:** -

The Faculty Higher Degrees Committee has scrutinised your research proposal and concluded that it complies with the approved research standards of the Faculty of Health Sciences; University of Johannesburg.

The HDC would like to extend their best wishes to you with your postgraduate studies

Yours sincerely,

Prof S Nalla
Chair: Faculty of Health Sciences HDC
Tel: 011 559 6258
Email: shahedn@uj.ac.za

APPENDIX F – Research Ethics Committee Letter

FACULTY OF HEALTH SCIENCES
RESEARCH ETHICS COMMITTEE

NHREC Registration: REC 241112-035

ETHICAL CLEARANCE LETTER
(RECX 2.0)

Student/Researcher Name	Marius Steenkamp	Student Number	201007209
Supervisor Name	Hay, Caroline		
Department	Chiropractic		
Research Title	INJURY INCIDENCE AND RISK FACTORS IN CROSSFIT® ATHLETES IN JOHANNESBURG		
Date	24 April 2020	Clearance Number	**REC-453-2020**

Approval of the research proposal with details given above is granted, subject to any conditions under 1 below, and is valid until 2021/04/23.

1. Conditions:
None.

2. Renewal:
It is required that this ethical clearance is renewed annually, within two weeks of the date indicated above. Renewal must be done using the Ethical Clearance Renewal Form (REC 10.0), to be completed and submitted to the Faculty Administration office. *See Section 12 of the REC Standard Operating Procedures.*

3. Amendments:
Any envisaged amendments to the research proposal that has been granted ethical clearance must be submitted to the REC using the Research Proposal Amendment Application Form (REC 8.0) prior to the research being amended. Amendments to research may only be carried out once a new ethical clearance letter is issued. *See Section 13 of the REC Standard Operating Procedures.*

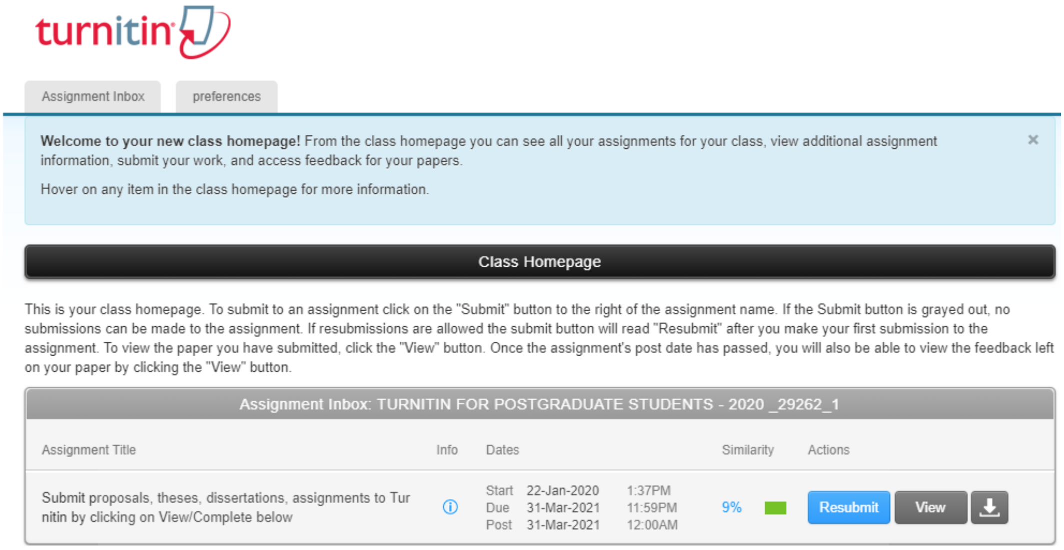
4. Adverse Events, Deviations or Non-compliance:
Adverse events, research proposal deviations or non-compliance must be reported within the stipulated time-frames using the Adverse Event Reporting Form (REC 9.0). *See Section 14 of the REC Standard Operating Procedures.*

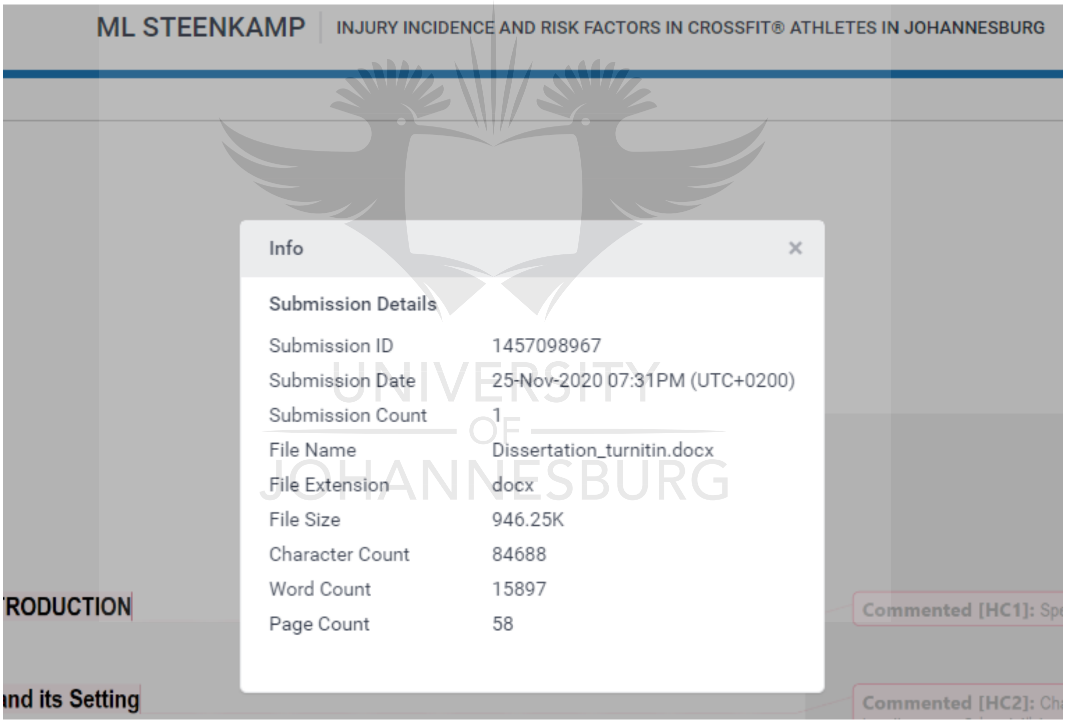
The REC wishes you all the best for your studies.

Yours sincerely,

Prof. Christopher Stein
Chairperson: REC
Tel: 011 559 6564
Email: cstein@uj.ac.za

APPENDIX G – Turnitin Report





APPENDIX H – Table A1: Table depicting the number of mobility sessions in relation to diagnoses

			No diagnosis was made	Overuse	General inflammation and pain	Stress fracture	Strain/pain	Rupture	Dislocation	Unspecified pain	Other	Total
rB3	1-3	Count	8	11	19	1	16	1	1	1	4	62
		% within rB3	12.9%	17.7%	30.6%	1.6%	25.8%	1.6%	1.6%	1.6%	6.5%	
	4	Count	11	14	22	4	19	6	1	2	3	82
		% within rB3	13.4%	17.1%	26.8%	4.9%	23.2%	7.3%	1.2%	2.4%	3.7%	
	5	Count	2	15	26	3	19	4	1	2	3	75
		% within rB3	2.7%	20.0%	34.7%	4.0%	25.3%	5.3%	1.3%	2.7%	4.0%	
	More than 5	Count	4	19	23	3	21	2	0	0	5	77
		% within rB3	5.2%	24.7%	29.9%	3.9%	27.3%	2.6%	0.0%	0.0%	6.5%	
Total		Count	25	59	90	11	75	13	3	5	15	296

APPENDIX I – Table A2: Table depicting the number of CrossFit® training sessions in relation to diagnoses

			No diagnosis was made	Overuse	General inflammation and pain	Stress fracture	Strain/pain	Rupture	Dislocation	Unspecified pain	Other	Total
rB6	1-2	Count	6	6	18	1	13	2	1	0	5	52
		% within rB6	11.5%	11.5%	34.6%	1.9%	25.0%	3.8%	1.9%	0.0%	9.6%	
	3	Count	9	17	28	5	27	6	1	2	7	102
		% within rB6	8.8%	16.7%	27.5%	4.9%	26.5%	5.9%	1.0%	2.0%	6.9%	
	4 or more	Count	9	34	43	5	35	5	1	3	3	138
		% within rB6	6.5%	24.6%	31.2%	3.6%	25.4%	3.6%	0.7%	2.2%	2.2%	
Total		Count	24	57	89	11	75	13	3	5	15	292